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San Francisco International Airport Environmental Impact Assessment Report Airport Improvement Program

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San Francisco Airport Commission

SAN FRANCISCO INTERNATIONAL AIRPORT

EXPANSION PROGRAM

ENVIRONMENTAL IMPACT ASSESSMENT REPORT

VOLUME II

Part 1

Prepared by:

Landrum & Brown
Airport Consultants

May, 1975

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THIS VOLUME IS DIVIDED INTO TWO PARTS

PART 1 CONTAINS:

- APPENDIX A - UPDATE OF THE AIRPORT FACILITY REQUIREMENTS DATA BASE
- APPENDIX B - NOISE IMPACT
- APPENDIX C - GROUND ACCESS

PART 2 CONTAINS:

- APPENDIX D - AIR QUALITY
- APPENDIX E - WATER USAGE AND WASTE WATER GENERATION
- APPENDIX F - GEOLOGICAL ASPECTS OF THE SAN FRANCISCO INTERNATIONAL AIRPORT EXPANSION PROGRAM
- APPENDIX G - OTHER ISSUES
- APPENDIX H - ANALYSIS OF BENEFITS AND COSTS

TABLE OF CONTENTS

		Page
APPENDIX A - UPDATE OF THE AIRPORT FACILITY REQUIREMENTS DATA BASE		
1.	INTRODUCTION	A-1
2.	THE ELEMENTS OF AVIATION DEMAND	A-2
3.	AIR PASSENGER FORECASTS	A-10
4.	FORECASTS OF OPERATIONS AND FLEET MIX	A-14
5.	THE "DO-NOTHING" FORECAST	A-26
6.	PURPOSE AND SCOPE OF THE DEMAND/CAPACITY ANALYSIS	A-29
7.	AIRFIELD DEMAND/CAPACITY ANALYSIS METHODOLOGY	A-30
8.	FINDINGS OF THE AIRFIELD DEMAND/CAPACITY ANALYSIS	A-39
9.	AIRPORT FACILITY REQUIREMENTS	A-39
APPENDIX B - NOISE IMPACT		
1.	INTRODUCTION	B-1
2.	GENERAL DISCUSSION OF NOISE IMPACT ANALYSIS	B-2
3.	DESCRIPTION OF METHODOLOGY	B-15
4.	INPUT REQUIREMENTS	B-21
5.	IMPACT ANALYSIS	B-45

TABLE OF CONTENTS

		Page
APPENDIX C - GROUND ACCESS		
1.	INTRODUCTION	C-2
2.	ACCESS FACILITIES	C-6
3.	METHODOLOGY	C-10
4.	SIMULATION OF DESIGN DAY CONDITIONS - 1974	C-23
5.	SIMULATION OF DESIGN DAY TRAFFIC - 1982	C-28
6.	SIMULATION OF DESIGN DAY TRAFFIC - 1990	C-31
7.	IMPACT ASSESSMENT	C-37
8.	MITIGATING MEASURES	C-63
9.	SUMMARY AND CONCLUSIONS	C-66
APPENDIX D - AIR QUALITY		
1.	INTRODUCTION	D-2
2.	LOCAL SETTING	D-7
3.	AIRPORT ACTIVITIES	D-16
4.	EVALUATION METHODOLOGY	D-24
5.	IMPACT ASSESSMENT	D-37
APPENDIX E - WATER USAGE AND WASTE WATER GENERATION		
1.	INTRODUCTION	E-1
2.	WATER REQUIREMENTS	E-2
3.	WASTE WATER GENERATION	E-5
4.	IMPACT OF FUTURE DEVELOPMENTS	E-15

TABLE OF CONTENTS

		Page
APPENDIX F -	GEOLOGICAL ASPECTS OF THE SAN FRANCISCO INTERNATIONAL AIRPORT EXPANSION PROGRAM	
1.	INTRODUCTION	F-1
2.	GEOLOGY OF BAY AREA	F-2
3.	SEISMIC EFFECTS	F-8
4.	TSUNAMI AND SEICH EFFECTS	F-11
5.	IMPACT ASSESSMENT	F-13
APPENDIX G -	OTHER ISSUES	
1.	INTRODUCTION	G-1
2.	AESTHETICS	G-2
3.	FUEL AND ENERGY	G-6
4.	BAY FILL	G-18
5.	HYDROLOGICAL CONSIDERATIONS	G-19
6.	SOLID WASTES	G-20
7.	WILDLIFE	G-24
8.	RECREATIONAL SITES	G-27
9.	HISTORICAL SITES	G-30

TABLE OF CONTENTS

		Page
APPENDIX H - ANALYSIS OF BENEFITS AND COSTS		
1.	INTRODUCTION	H-1
2.	APPROACH TO THE PROBLEM	H-3
3.	DESCRIPTION OF THE STUDY AREA	H-5
4.	ENVIRONMENTAL EFFECTS	H-6
5.	GROUND ACCESS EFFECTS	H-18
6.	SOCIO-ECONOMIC EFFECTS	H-25
7.	SUMMARY OF BENEFITS AND COSTS	H-40

LIST OF EXHIBITS

Exhibit	Title	Following Page
A-1	SUMMARY OF PREVIOUS AVIATION DEMAND FORECASTS	A-5
A-2	FORECASTS OF TOTAL ANNUAL ON AND OFF PASSENGERS	A-10
A-3	FORECASTS OF AVERAGE SEATS PER OPERATION	A-15
A-4	DERIVATION OF 1973 AVERAGE SEATS PER OPERATION	A-17
A-5	FORECASTS OF ANNUAL BOARDING LOAD FACTOR	A-19
A-6	SUMMARY OF PASSENGER AND OPERATIONS FORECASTS	A-21
A-7	AIRCRAFT FLEET MIX FORECAST	A-23
A-8	AIRSPACE DEFINITIONS	A-32
A-9	OPERATING CONFIGURATIONS/PERCENT UTILIZATIONS	A-34
A-10	RUNWAY RATINGS	A-36
A-11	INVENTORY OF NAVIGATIONAL AIDS	A-37
A-12	AIRCRAFT CLASSIFICATIONS	A-39
A-13	HOURLY CAPACITY DATA	A-40
A-14	ANNUAL CAPACITY AND DELAY	A-41

LIST OF EXHIBITS

Exhibit	Title	Following Page
B-1	TYPICAL FLYOVER SIGNAL	B-5
B-2	PLANNING GUIDELINES	B-10
B-3	MARCO FLOW CHART OF CNEL COMPUTER PROGRAM LOGIC	B-17
B-4	ASDS SINGLE EVENT SOUND CONTOUR, B-727-100	B-19
B-5	RUNWAY DISTRIBUTIONS BY TIME OF DAY	B-22
B-6	DAILY OPERATIONS	B-26
B-7	AIRCRAFT TYPES USED FOR ASDS ANALYSIS	B-27
B-8	STAGE LENGTH DISTRIBUTION	B-29
B-9	TAKEOFF WEIGHTS FOR ASDS	B-30
B-10	FLIGHT TRACK GEOMETRY	B-32
B-11	DEPARTURE FLIGHT TRACK DISTRIBUTIONS	B-34
B-12	FLIGHT TRACK SEGMENTS	B-35
B-13	FLIGHT TRACK SEGMENTS DISTRIBUTION	B-36
B-14	EXAMPLE OF INPUT DATA	B-40
B-15	LAND USE MAP	B-48
B-16	STUDY ZONES	B-49
B-17	POPULATION AND DWELLING UNIT PARAMETERS	B-51
B-18	1974 CNEL AVERAGE ANNUAL DAY NOISE CONTOURS	B-52

LIST OF EXHIBITS

Exhibit	Title	Following Page
B-19	1974 CNEL AVERAGE SEASONAL DAY NOISE CONTOURS	B-53
B-20	1974 ASDS AVERAGE ANNUAL DAY NOISE CONTOURS	B-55
B-21	1974 ASDS AVERAGE SEASONAL DAY NOISE CONTOURS	B-56
B-22	NOISE IMPACT SUMMARY CNEL 1974	B-58
B-23	NOISE IMPACT SUMMARY ASDS 1974	B-59
B-24	1982 CNEL AVERAGE ANNUAL DAY NOISE CONTOURS	B-60
B-25	1982 CNEL AVERAGE SEASONAL DAY NOISE CONTOURS	B-61
B-26	1982 ASDS AVERAGE ANNUAL DAY NOISE CONTOURS	B-62
B-27	1982 ASDS AVERAGE SEASONAL DAY NOISE CONTOURS	B-64
B-28	NOISE IMPACT SUMMARY CNEL 1982	B-65
B-29	NOISE IMPACT SUMMARY ASDS 1982	B-66
B-30	1990 AVERAGE ANNUAL DAY CNEL CONTOURS	B-68
B-31	1990 AVERAGE SEASONAL DAY CNEL CONTOURS	B-69
B-32	1990 AVERAGE ANNUAL DAY ASDS CONTOURS	B-70
B-33	1990 AVERAGE SEASONAL DAY ASDS CONTOURS	B-71
B-34	NOISE IMPACT SUMMARY CNEL 1990	B-72

LIST OF EXHIBITS

Exhibit	Title	Following Page
B-35	NOISE IMPACT SUMMARY ASDS 1990	B-73
B-36	CNEL SUMMARY	B-79
B-37	ASDS SUMMARY	B-80
B-38	NOISE IMPACT SUMMARY	B-81
C-1	ACCESS FACILITIES	C-6
C-2	EXISTING PARKING FACILITIES	C-10
C-3	VEHICLE OCCUPANCY RATES	C-12
C-4	1974 SURVEY DAY AIR PASSENGERS	C-18
C-5	1974 SURVEY DAY ESTIMATED EMPLOYMENT DISTRIBUTION BY CATEGORY	C-19
C-6	1974 SURVEY DAY AIRPORT POPULATION	C-20
C-7	1974 SURVEY DAY TOTAL PERSON TRIPS	C-20
C-8	1974 SURVEY DAY MODE SPLIT DISTRIBUTION TOTAL AIR PASSENGERS PERSON TRIPS	C-21
C-9	1974 SURVEY DAY MODE SPLIT DISTRIBUTION TOTAL NON-AIR PASSENGER PERSON TRIPS	C-21
C-10	1974 SURVEY DAY MODE SPLIT DISTRIBUTION TOTAL EMPLOYEE PERSON TRIPS	C-21
C-11	1974 SURVEY DAY MODE SPLIT DISTRIBUTION TOTAL PERSON TRIPS	C-21
C-12	1974 SURVEY DAY TOTAL VEHICLE TRIPS	C-22

LIST OF EXHIBITS

Exhibit	Title	Following Page
C-13	SURVEY DAY TRAFFIC	C-22
C-14	1974 DESIGN DAY AIR PASSENGERS	C-24
C-15	1974 DESIGN DAY AIRPORT POPULATION	C-24
C-16	1974 DESIGN DAY TOTAL PERSON TRIPS	C-24
C-17	1974 DESIGN DAY MODE SPLIT DISTRIBUTION TOTAL AIR PASSENGER PERSON TRIPS	C-25
C-18	1974 DESIGN DAY MODE SPLIT DISTRIBUTION TOTAL PERSON TRIPS	C-26
C-19	1974 DESIGN DAY TOTAL VEHICLE TRIPS	C-26
C-20	1974 DESIGN DAY TRAFFIC	C-26
C-21	1974 DESIGN DAY TRAFFIC	C-26
C-22	1974 AVERAGE ANNUAL DAILY TRAFFIC	C-27
C-23	1974 AVERAGE ANNUAL DAILY TRAFFIC	C-27
C-24	1982 DESIGN DAY ESTIMATED AIRPORT POPULATION	C-29
C-25	1982 DESIGN DAY MODE SPLIT DISTRIBUTION TOTAL PERSON TRIPS	C-30
C-26	1982 DESIGN DAY TOTAL VEHICLE TRIPS	C-30
C-27	1982 DESIGN DAY TRAFFIC	C-31
C-28	1982 DESIGN DAY TRAFFIC	C-31
C-29	1982 AVERAGE ANNUAL DAILY TRAFFIC	C-31
C-30	1982 AVERAGE ANNUAL DAILY TRAFFIC	C-31

LIST OF EXHIBITS

Exhibit	Title	Following Page
C-31	1990 DESIGN DAY AIRPORT POPULATION	C-31
C-32	1990 DESIGN DAY MODE SPLIT DISTRIBUTION TOTAL PERSON TRIPS WITHOUT RAPID TRANSIT	C-32
C-33	1990 DESIGN DAY TOTAL VEHICLE TRIPS WITHOUT RAPID TRANSIT	C-33
C-34	1990 DESIGN DAY TRAFFIC WITHOUT RAPID TRANSIT	C-33
C-35	1990 DESIGN DAY TRAFFIC WITHOUT RAPID TRANSIT	C-33
C-36	1990 AVERAGE ANNUAL DAILY TRAFFIC WITHOUT RAPID TRANSIT	C-33
C-37	1990 AVERAGE ANNUAL DAILY TRAFFIC WITHOUT RAPID TRANSIT	C-33
C-38	RAPID TRANSIT EXTENSION - DALY CITY TO AIRPORT	C-34
C-39	1990 DESIGN DAY MODE SPLIT DISTRIBUTION TOTAL PERSON TRIPS WITH RAPID TRANSIT	C-35
C-40	1990 DESIGN DAY TOTAL VEHICLE TRIPS WITH RAPID TRANSIT	C-35
C-41	1990 DESIGN DAY TRAFFIC WITH RAPID TRANSIT	C-36
C-42	1990 DESIGN DAY TRAFFIC WITH RAPID TRANSIT	C-36
C-43	1990 AVERAGE ANNUAL DAILY TRAFFIC WITH RAPID TRANSIT	C-36
C-44	1990 AVERAGE ANNUAL DAILY TRAFFIC WITH RAPID TRANSIT	C-36

LIST OF EXHIBITS

Exhibit	Title	Following Page
C-45	ON-AIRPORT ROADWAY DESIGNATIONS	C-39
C-46	ON-AIRPORT INTERSECTION CAPACITY ANALYSIS	C-39
C-47	OFF-AIRPORT INTERSECTION CAPACITY ANALYSIS	C-40
C-48	1974 DESIGN DAY PEAK HOUR WEAVING SECTION ANALYSIS MAIN ACCESS ROADWAY	C-40
C-49	PARKING GENERATION FACTORS	C-41
C-50	RATIOS OF PEAK ACCUMULATIONS TO TOTAL WEEKLY PARKERS	C-41
C-51	AIRPORT PARKERS FOR TYPICAL WEEK IN AUGUST	C-43
C-52	1974 GARAGE ANALYSIS ACCUMULATION OF PARKED VEHICLES	C-43
C-53	1974 CURB FRONTAGE ANALYSIS ENPLANING ROADWAY - SOUTH TERMINAL	C-44
C-54	1974 CURB FRONTAGE ANALYSIS DEPLANING ROADWAY - SOUTH TERMINAL	C-44
C-55	1974 CURB FRONTAGE ANALYSIS ENPLANING ROADWAY - CENTRAL TERMINAL	C-44
C-56	1974 CURB FRONTAGE ANALYSIS DEPLANING ROADWAY - CENTRAL TERMINAL	C-44
C-57	1974 DESIGN DAY OFF-AIRPORT HIGHWAY UTILIZATION	C-46
C-58	1982 DESIGN DAY PEAK HOUR ON AIRPORT INTERSECTION CAPACITY ANALYSIS	C-48

LIST OF EXHIBITS

Exhibit	Title	Following Page
C-59	1982 DESIGN DAY OFF-AIRPORT INTERSECTION CAPACITY ANALYSIS	C-49
C-60	1982 DESIGN DAY PEAK HOUR WEAVING SECTION ANALYSIS MAIN ACCESS ROADWAY	C-49
C-61	1982 DESIGN CONDITIONS AIRPORT PARKERS FOR TYPICAL WEEK IN AUGUST	C-51
C-62	1982 GARAGE ANALYSIS ACCUMULATION OF PARKED VEHICLES	C-51
C-63	1982 CURB FRONTAGE ANALYSIS ENPLANING ROADWAY - WITHOUT EXPANSION	C-52
C-64	1982 CURB FRONTAGE ANALYSIS DEPLANING ROADWAY - WITHOUT EXPANSION	C-53
C-65	1982 CURB FRONTAGE ANALYSIS ENPLANING ROADWAY - WITH EXPANSION	C-53
C-66	1982 CURB FRONTAGE ANALYSIS DEPLANING ROADWAY - WITH EXPANSION	C-53
C-67	1982 DESIGN DAY OFF-AIRPORT HIGHWAY UTILIZATION	C-54
C-68	1990 DESIGN DAY PEAK HOUR ON-AIRPORT INTERSECTION CAPACITY ANALYSIS	C-55
C-69	1990 DESIGN DAY OFF-AIRPORT INTERSECTION CAPACITY ANALYSIS	C-56
C-70	1990 DESIGN DAY PEAK HOUR WITHOUT RAPID TRANSIT WEAVING SECTION ANALYSIS MAIN ACCESS ROADWAY	C-56

LIST OF EXHIBITS

Exhibit	Title	Following Page
C-71	1990 DESIGN DAY PEAK HOUR WITH RAPID TRANSIT WEAVING SECTION ANALYSIS MAIN ACCESS ROADWAY	C-57
C-72	1990 DESIGN CONDITIONS AIRPORT PARKERS FOR TYPICAL WEEK IN AUGUST	C-58
C-73	1990 GARAGE ANALYSIS ACCUMULATION OF PARKED VEHICLES - WITHOUT RAPID TRANSIT	C-58
C-74	1990 CURB FRONTAGE ANALYSIS ENPLANING ROADWAY - WITHOUT EXPANSION	C-60
C-75	1990 CURB FRONTAGE ANALYSIS DEPLANING ROADWAY - WITHOUT EXPANSION	C-60
C-76	1990 CURB FRONTAGE ANALYSIS ENPLANING ROADWAY - WITH EXPANSION	C-60
C-77	1990 CURB FRONTAGE ANALYSIS DEPLANING ROADWAY - WITH EXPANSION	C-60
C-78	1990 CURB FRONTAGE ANALYSIS ENPLANING ROADWAY - WITH EXPANSION AND RAPID TRANSIT	C-61
C-79	1990 CURB FRONTAGE ANALYSIS DEPLANING ROADWAY - WITH EXPANSION AND RAPID TRANSIT	C-61
C-80	1990 DESIGN DAY WITHOUT RAPID TRANSIT OFF-AIRPORT HIGHWAY UTILIZATION	C-62
C-81	1990 DESIGN DAY WITH RAPID TRANSIT OFF-AIRPORT HIGHWAY UTILIZATION	C-62
C-82	SUMMARY OF ON-AIRPORT INTERSECTION LEVEL OF SERVICE FOR ALTERNATIVE CONDITIONS	C-66

LIST OF EXHIBITS

Exhibit	Title	Following Page
C-83	SUMMARY OF DESIGN DAY OFF-AIRPORT INTERSECTION CAPACITY ANALYSIS	C-67
C-84	SUMMARY OF WEAVING SECTION ANALYSIS SOUTH RAMPS - MAIN ROADWAY DESIGN DAY - PEAK HOUR	C-68
C-85	ANALYSIS OF PUBLIC PARKING FACILITIES	C-70
C-86	SUMMARY OF CURB FRONTAGE ANALYSIS	C-70
C-87	OFF-AIRPORT HIGHWAY UTILIZATION	C-71
D-1	HISTORY AND TRENDS IN AMBIENT AIR QUALITY	D-8
D-2	SUMMARY OF IMPACT OF CONTROL STRATEGIES IN SAN FRANCISCO BAY REGION IN 1977	D-8
D-3	HIGH HOUR OXIDANT CONCENTRATIONS AT BURLINGAME	D-9
D-4	MONTHLY AVERAGE HIGH HOUR CARBON MONOXIDE CONCENTRATIONS AT BURLINGAME	D-9
D-5	AVERAGE OF MONTH'S 24 HOUR SULPHUR DIOXIDE MEASUREMENTS AT BURLINGAME	D-9
D-6	MAXIMUM OF MONTH'S 24 HOUR SUSPENDED PARTICULATE MEASUREMENTS AT BURLINGAME	D-9
D-7	MONTHLY AVERAGE OF HIGH HOUR NITROGEN DIOXIDE MEASUREMENTS AT REDWOOD CITY	D-9
D-8	PERCENTAGE FREQUENCY OF INVERSIONS AT 3500 FEET OR LESS	D-12
D-9	VISIBILITY AND CIRCULATION PATTERNS	D-13

LIST OF EXHIBITS

Exhibit	Title	Following Page
D-10	NORTH WIND FLOW PATTERNS	D-13
D-11	NORTHEAST WIND FLOW PATTERNS	D-13
D-12	EAST WIND FLOW PATTERNS	D-13
D-13	SOUTHEAST WIND FLOW PATTERNS	D-13
D-14	SOUTH WIND FLOW PATTERNS	D-13
D-15	SOUTHWEST WIND FLOW PATTERNS	D-13
D-16	WEST WIND FLOW PATTERNS	D-13
D-17	NORTHWEST WIND FLOW PATTERNS	D-13
D-18	JANUARY MEAN MAXIMUM TEMPERATURES	D-14
D-19	JANUARY MEAN MINIMUM TEMPERATURES	D-14
D-20	JULY MEAN MAXIMUM TEMPERATURES	D-14
D-21	JULY MEAN MINIMUM TEMPERATURES	D-14
D-22	MEAN ANNUAL TOTAL PRECIPITATION	D-15
D-23	AIR POLLUTION POTENTIAL FOR AREAS AROUND MAJOR AIRPORT SITES	D-16
D-24	AVERAGE ANNUAL EMISSIONS FROM TRANSPORTATION SECTOR	D-17
D-25	SCHEMATIC DESCRIPTION OF DEMANDS AND SOURCE OF AIR POLLUTION	D-18
D-26	EMISSION CHARACTERISTIC OF AIRCRAFT ENGINES	D-18

LIST OF EXHIBITS

Exhibit	Title	Following Page
D-27	TRENDS IN CIVILIAN AIRCRAFT EMISSIONS 1950 - 1980	D-18
D-28	EMISSION OF AIR POLLUTANTS FOR HEATING PLANT	D-22
D-29	AIRPORT AIR QUALITY DISPERSION MODEL FUNCTIONAL FLOW DIAGRAM	D-26
D-30	FIELD MEASUREMENT LOCATIONS	D-30
D-31	CARBON MONOXIDE MONITORING DATA	D-31
D-32	METEOROLOGICAL SCENARIOS EVALUATED IN DISPERSION MODELING	D-33
D-33	FREQUENCY OF METEOROLOGICAL CONDITIONS BY WIND DIRECTION AND STABILITY CLASS ANNUAL 0700 - 1000 HOURS	D-33
D-34	FREQUENCY OF METEOROLOGICAL CONDITIONS BY WIND DIRECTION AND STABILITY CLASS DEC.-FEB. 1300 TO 1600 HOURS	D-33
D-35	FREQUENCY OF METEOROLOGICAL CONDITIONS BY WIND DIRECTION AND STABILITY CLASS DEC.-FEB. 0700 - 1000 HOURS	D-33
D-36	GROUND VEHICLE CARBON MONOXIDE, HYDRO-CARBON, NITROGEN OXIDE, PARTICULATE AND SULPHUR DIOXIDE EMISSION FACTORS BY MODE OF OPERATION	D-34
D-37-1	AIRCRAFT CARBON MONOXIDE EMISSION FACTOR BY MODE OF OPERATION FOR THE YEAR 1974	D-34

LIST OF EXHIBITS

Exhibit	Title	Following Page
D-37-2	AIRCRAFT HYDROCARBON EMISSION FACTOR BY MODE OF OPERATION FOR THE YEAR 1974	D-34
D-37-3	AIRCRAFT NITROGEN OXIDES EMISSION FACTOR BY MODE OF OPERATION FOR THE YEAR 1974	D-34
D-37-4	AIRCRAFT PARTICULATES EMISSION FACTOR BY MODE OF OPERATION FOR THE YEAR 1974	D-34
D-37-5	AIRCRAFT SULPHUR OXIDES EMISSION FACTOR BY MODE OF OPERATION FOR THE YEAR 1974	D-34
D-38-1	STATIONARY SOURCES EMISSION FACTORS	D-34
D-38-2	STATIONARY SOURCES EMISSION FACTORS	D-34
D-38-3	STATIONARY SOURCES EMISSION FACTORS	D-34
D-39	COMPARISON OF MEASURED AND CALCULATED CARBON MONOXIDE CONCENTRATIONS	D-35
D-40	AIR QUALITY EVALUATION SCENARIOS	D-35
D-41	AMBIENT AIR QUALITY STANDARDS	D-38
D-42	1974 CARBON MONOXIDE ISOPLETHS (PPM), MAXIMUM ONE-HOUR CONCENTRATIONS EXISTING AIRPORT	D-41
D-43	1982 CARBON MONOXIDE ISOPLETHS (PPM), MAXIMUM ONE-HOUR CONCENTRATIONS NO FURTHER DEVELOPMENT	D-41
D-44	1982 CARBON MONOXIDE ISOPLETHS (PPM), MAXIMUM ONE-HOUR CONCENTRATIONS PROPOSED DEVELOPMENT	D-41

LIST OF EXHIBITS

Exhibit	Title	Following Page
D-45	1990 CARBON MONOXIDE ISOPLETHS (PPM), MAXIMUM ONE-HOUR CONCENTRATIONS NO FURTHER DEVELOPMENT	D-41
D-46	1990 CARBON MONOXIDE ISOPLETHS (PPM), MAXIMUM ONE-HOUR CONCENTRATIONS PROPOSED DEVELOPMENT W/O BART	D-41
D-47	1990 CARBON MONOXIDE ISOPLETHS (PPM), MAXIMUM ONE-HOUR CONCENTRATIONS PROPOSED DEVELOPMENT W/BART	D-41
D-48	1974 NITROGEN DIOXIDE ISOPLETHS (PPM), MAXIMUM ONE-HOUR CONCENTRATIONS EXISTING AIRPORT	D-41
D-49	1982 NITROGEN DIOXIDE ISOPLETHS (PPM), MAXIMUM ONE-HOUR CONCENTRATIONS NO FURTHER DEVELOPMENT	D-41
D-50	1982 NITROGEN DIOXIDE ISOPLETHS (PPM), MAXIMUM ONE-HOUR CONCENTRATIONS PROPOSED DEVELOPMENT	D-41
D-51	1990 NITROGEN DIOXIDE ISOPLETHS (PPM), MAXIMUM ONE-HOUR CONCENTRATIONS NO FURTHER DEVELOPMENT	D-41
D-52	1990 NITROGEN DIOXIDE ISOPLETHS (PPM), MAXIMUM ONE-HOUR CONCENTRATIONS PROPOSED DEVELOPMENT W/O BART	D-41
D-53	1990 NITROGEN DIOXIDE ISOPLETHS (PPM), MAXIMUM ONE-HOUR CONCENTRATIONS PROPOSED DEVELOPMENT W/BART	D-41
D-54	1974 HYDROCARBON ISOPLETHS (PPM), MAXIMUM ONE-HOUR CONCENTRATIONS EXISTING AIRPORT	D-41

LIST OF EXHIBITS

Exhibit	Title	Following Page
D-55	1982 HYDROCARBON ISOPLETHS (PPM), MAXIMUM ONE-HOUR CONCENTRATIONS NO FURTHER DEVELOPMENT	D-41
D-56	1982 HYDROCARBON ISOPLETHS (PPM), MAXIMUM ONE-HOUR CONCENTRATIONS PROPOSED DEVELOPMENT	D-41
D-57	1990 HYDROCARBON ISOPLETHS (PPM), MAXIMUM ONE-HOUR CONCENTRATIONS NO FURTHER DEVELOPMENT	D-41
D-58	1990 HYDROCARBON ISOPLETHS (PPM), MAXIMUM ONE-HOUR CONCENTRATIONS PROPOSED DEVELOPMENT W/O BART	D-41
D-59	1990 HYDROCARBON ISOPLETHS (PPM), MAXIMUM ONE-HOUR CONCENTRATIONS PROPOSED DEVELOPMENT W/BART	D-41
D-60	1974 PARTUCLATES ISOPLETHS (ug/m^3) MAXIMUM 24-HOUR CONCENTRATIONS EXISTING AIRPORT	D-41
D-61	1982 PARTICULATE ISOPLETHS (ug/m^3) MAXIMUM 24-HOUR CONCENTRATIONS NO FURTHER DEVELOPMENT	D-41
D-62	1982 PARTICULATE ISOPLETHS (ug/m^3) MAXIMUM 24-HOUR CONCENTRATIONS PROPOSED DEVELOPMENT	D-41
D-63	1990 PARTICULATE ISOPLETHS (ug/m^3) MAXIMUM 24-HOUR CONCENTRATIONS NO FURHTER DEVELOPMENT	D-41
D-64	1990 PARTICULATE ISOPLETHS (ug/m^3) MAXIMUM 24-HOUR CONCENTRATIONS PROPOSED DEVELOPMENT W/O BART	D-41

LIST OF EXHIBITS

Exhibit	Title	Following Page
D-65	1990 PARTICULATE ISOPLETHS (ug/m^3) MAXIMUM 24-HOUR CONCENTRATIONS PROPOSED DEVELOPMENT W/BART	D-41
D-66	PREDICTED ONE-HOUR CONCENTRATIONS OF CARBON MONOXIDE	D-42
D-67	PREDICTED EIGHT-HOUR CONCENTRATIONS OF CARBON MONOXIDE	D-42
D-68	PREDICTED ONE-HOUR CONCENTRATIONS OF NITROGEN OXIDES	D-42
D-69	PREDICTED ONE-HOUR CONCENTRATIONS OF HYDROCARBONS	D-42
D-70	PREDICTED 24-HOUR CONCENTRATIONS OF PARTICULATES	D-42
D-71	PREDICTED ONE-HOUR CONCENTRATIONS OF SULPHUR DIOXIDE	D-42
D-72	DEFINITION OF SELECTED LOCATIONS FOR DETERMINATION OF AIR QUALITY	D-42
D-73	SELECTED LOCATIONS FOR DETERMINATION OF PREDICTED AIR QUALITY LEVELS	D-42
D-74	EMISSION INVENTORY FOR SIX SCENARIOS	D-46
D-75	SUMMARY OF TOTAL EMISSIONS AND APPROXIMATE CONTRIBUTION TO TOTAL AIRPORT VICINITY EMISSIONS BY SOURCE	D-46
D-76	SUMMARY OF AIRPORT RELATED VMT	D-47

LIST OF EXHIBITS

Exhibit	Title	Following Page
E-1	SANITARY WASTE FLOWS	E-6
E-2	NORMALIZED SANITARY WASTE FLOWS	E-6
E-3	CHARACTERISTICS OF INDUSTRIAL WASTE-WATERS	E-8
E-4	STORM RUNOFF ESTIMATES	E-8
E-5	SEWERAGE UTILITIES PLAN	E-9
E-6	SANITARY SEWAGE TREATMENT PLANTS	E-10
E-7	TREATMENT FLOW DIAGRAM	E-10
E-8	SANITARY TREATMENT PLANT DESIGN CRI-TERIA	E-10
E-9	DRAINAGE UTILITIES PLAN	E-10
E-10	VIOLATION CITATION FORM	E-14
E-11	INDUSTRIAL WASTEWATER TREATMENT PRO-POSED COLLECTION SYSTEM SEPTEMBER 1973	E-14
E-12	GENERAL INDUSTRIAL WASTE TREATMENT FLOW DIAGRAM	E-15
E-13	EFFLUENT DISCHARGE REQUIREMENTS	E-15
F-1	LOCATION AND MAGNITUDE OF EARTHQUAKES IN THE BAY AREA (1934-1965)	F-4
F-2	ENGINEERING PROPERTIES OF BAY MUDS	F-5
F-3	AIRPORT SUPERIMPOSED ON 1930 TOPOGRAPHY	F-7
F-4	BEHAVIOR OF SOIL AND FILL MATERIALS UNDER LOADINGS	F-9
F-5	AREAS OF TSUNAMI RUN UP	F-12

LIST OF EXHIBITS

Exhibit	Title	Following Page
G-1	PREDICTED AVIATION FUEL CONSUMPTION	G-9
G-2	NATURAL GAS CONSUMPTION AT SFIA	G-12
G-3	ELECTRICAL POWER CONSUMPTION AT SFIA	G-14
G-4	VEHICLE GASOLINE CONSUMPTION	G-15
G-5	SUMMARY OF ENERGY IMPACT	G-17
G-6	SOLID WASTES AT SFIA	G-21
G-7	PACIFIC FLYWAY	G-25
G-8	SAN FRANCISCO BAY IN SAN FRANCISCO INTERNATIONAL AIRPORT AREA	G-25
G-9	RESPONSE OF CALIFORNIA DEPARTMENT OF FISH AND GAME	G-26
G-10	RESPONSE OF UNITED STATES DEPARTMENT OF THE INTERIOR	G-26
G-11	SAN FRANCISCO BAY NORTHERN SAN MATEO COUNTY	G-28
G-12	RESPONSE OF DEPARTMENT OF PARKS AND RECREATION	G-30
H-1	AIR POLLUTION EMISSIONS	H-9
H-2	NOISE IMPACT SUMMARY	H-11
H-3	WATER QUALITY IMPACT	H-13
H-4	SOLID WASTE IMPACT	H-15

LIST OF EXHIBITS

Exhibit	Title	Following Page
H-5	ENERGY IMPACT	H-17
H-6	GROUND ACCESS IMPACTS	H-20
H-7	AIRPORT-RELATED EMPLOYMENT--1975	H-29
H-8	PROJECTIONS OF AIRPORT-RELATED EMPLOYMENT	H-32
H-9	AIRPORT-RELATED PAYROLL	H-34
H-10	AIRPORT INDUCED EXPENDITURE EFFECT	H-36
H-11	SUMMARY OF BENEFIT AND COST INDICATORS	H-43

APPENDIX A

UPDATE OF THE

AIRPORT FACILITY REQUIREMENTS

DATA BASE

APPENDIX A

UPDATE OF THE AIRPORT FACILITY REQUIREMENTS DATA BASE

Throughout its history, the U.S. air transportation industry has grown continuously, making ever greater contributions to the nation's economic well being and to the quality of life of much of its population. Growth of the national aviation system has been paced by continually rising demands for air transportation service, and while the rate of growth of demand has varied over the years, it has nevertheless been virtually uninterrupted.

This history of continuous, uninterrupted growth has made it clear that the operators of the nation's public airports have a continuing responsibility to maintain a vigilant watch on trends in the public demand for air transportation service, and to plan and develop the airport facilities required to provide that service.

1. INTRODUCTION

This appendix describes the forward thinking done by those responsible for the continuing development and operation of San Francisco International Airport (SFIA). Specifically, it presents the San Francisco Airport Authority's forecasts of future levels of aviation demand and discusses the implications of those forecasts on facility needs at SFIA.

San Francisco International Airport is principally an air carrier airport. As such, its function is to serve the traveling public--air passengers. For this reason, aircraft traffic at SFIA is made up principally of air carrier aircraft operations.

In this study, forecasts of passenger and aircraft activity were essential to analysis of the impacts, both on the environment and the airport access system, of the proposed expansion program. In support of this analysis, a number of previously developed forecasts of passenger and aircraft activity were reviewed and a preferred set of forecast figures was selected for use in the analysis.

2. THE ELEMENTS OF AVIATION DEMAND

Throughout this study and its documentation, there will be found discussions of the passenger forecasts for SFIA. In many instances, however, the numbers will not be the same. To clarify any possible misunderstandings because of this, the following definitions should be remembered:

- True Origin and Destination (O&D) Passengers: Those passengers whose trips either originate or terminate at SFIA.
- Connecting Passengers: Passengers whose trips neither originate nor terminate at SFIA, but who transfer from one aircraft to another.
- Through Passengers: Passengers whose destination is not San Francisco, but who are aboard an aircraft that stops in San Francisco enroute to other destinations and generally do not get off the aircraft.

- Enplaning Passengers: The sum of originating passengers and connecting passengers.

- Deplaning Passengers: The sum of those passengers whose destination is San Francisco and connecting passengers.

- On and Off Passengers: The sum of enplaning and deplaning passengers.

- In and Out Passengers: The sum of on and off passengers and through passengers.

- Aircraft Operations: Landings or takeoffs performed by aircraft.

Generally, forecasting work is done in terms of either O&D or enplaning and deplaning (on and off) passengers. In the case of SFIA, previous forecasts were developed for on and off passengers. However, the "in and out" passengers are basic to the arriving and departing aircraft load factors. It is these figures that contribute to the development of aircraft operations forecasts, as discussed later in this appendix.

In analysis of terminal facilities, on and off passengers would be considered, because they are the ones that use the terminal building. For access analysis, however, the appropriate figures to use are those for origin and destination passengers, because these are the passengers who travel to and from the airport on the highway network. At SFIA, O&D passengers currently average about 88 percent of the on and off totals, with the remainder being connections. Consequently, one would not use the same set of figures for access studies as one would for terminal analysis.

To avoid confusion, this report and all its appendices present the forecasts in terms of total, or in and out passengers. For 1974, on and off passengers constituted approximately 92.6 percent of total in and out passengers, i.e., through passengers accounted for approximately 7.4 percent of total passengers. It was assumed that this relationship would hold true throughout the forecast period. Throughout the study, whenever it was necessary to derive on and off passengers, the above relationship was used.

The sections that follow describe the process of developing and selecting forecasts for use in this study.

(1) History of Aviation Demand Forecast Development for SFIA

Since 1968, a number of forecasts of aviation demand have been made for SFIA. These include:

- Forecasts by Systems Analysis Research Corporation (SARC) for the Association of Bay Area Governments (ABAG) in support of the Regional Airport System Study (RASS). (1) 1/
- Three forecasts by ABAG; called RASS I, RASS II and RASS II (modified) for convenience. (2)
- The California State Department of Aeronautics forecasts. (3)
- The Air Transport Association (ATA) forecasts. (4)
- The Federal Aviation Administration forecasts. (5)

1/ Numbers in parenthesis refer to the list of references at the end of this Appendix.

Exhibit A-1 summarizes these forecasts in tabular form.[1/]

The original forecasts were developed by Systems Analysis Research Corporation (SARC) in 1970. Stepwise regression analysis utilizing population, income, and employment (from Bay Area Transportation Study Commission (BATSC) 1965 forecasts) as the independent variables were used to obtain the basic projections. Judgment multipliers of 1.04, 1.06 and 1.14 for 1975, 1980 and 1985 respectively, were applied to the basic projections to obtain the final forecasts. Passenger demand was forecast by zone and aggregated to produce a regional forecast.

The SARC forecasts were revised slightly by ABAG for inclusion in RASS. Population data for 1970 indicated a slower growth rate than SARC had assumed for the region. The original projection equation with the same coefficients was used along with the slightly more conservative population forecasts from the California Department of Finance. The income and employment forecasts remained unchanged. The same judgmental increases were applied to the projection equation to obtain the initial RASS forecasts (called RASS I). These forecasts appeared in the RASS final plan and were used in the recent EIR, which was developed by the City of San Francisco Planning Department and published August 10, 1973.

1/ Exhibit A-1 presents the forecasts in terms of on and off (enplaning and deplaning) passengers, as they were originally presented when developed. To convert to in and out (total) passengers, these figures should be increased by seven percent.

EXHIBIT A-1

San Francisco International Airport

SUMMARY OF PREVIOUS
AVIATION DEMAND FORECASTS

Source	Millions of Passengers (On and Off)				
	1975	1980	1985	1990 2/	1995
SARC					
RASS I	17.4	24.4	31.0	31.0	31.0
RASS II	16.5	23.5	30.0	31.0	31.0
RASS II Modified 1/	16.5	22.5	27.5	31.0	31.0
State Department of Aeronautics	16.0	20.2	24.9	28.5	31.5
FAA	NA	22.0	27.5	NA	NA
ATA	NA	20.7	25.0	31.0	31.0

NA - not available.

1/ Median value.

2/ All forecasts assume no growth after a level of 31,000,000 million passengers is reached. This is in accordance with the RASS recommendation that each Bay Area airport be allowed to grow to its ultimate capacity and no further.

The RASS I forecasts were updated in 1974 using the ABAG/MTC "Losouth" [2/] population/employment projections and the following adjustment factors: 0 to 5% for 1975, 0 to -5% for 1980 and -10 to -20% for 1985. The original regression equation coefficients developed by SARC in 1970 were used for the basic projection. These forecasts were identified as the RASS II forecast and were presented to the Regional Aviation Planning Committtee (RAPC) on November 25, 1974.

The RASS II forecasts were modified to take into consideration, to some degree, the State of California forecasts. The state forecasts were developed by Daniel, Mann, Johnson and Mendenhall. The methodology is a combination regression/gravity model that takes into account the available airport facilities. The RASS II forecasts were modified by applying judgment factors to arrive at the final forecasts. Thus the modified RASS II forecast used the original SARC equation with recent population/employment projections and judgement factors (RASS II) along with further judgment factors to reflect the state forecasts. The modified RASS II forecasts were adopted by RAPC on December 20, 1974.

The FAA forecasts were taken from Terminal Area Forecasts FY 1976-1986. The FAA utilizes a linear regression model with average revenue per passenger mile and average trip length as the independent

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2/ MTC is the Metropolitan Planning Commission and is responsible for maintaining the Airport Plan element of the Regional Transportation Plan. The Losouth population projection is one characterized by a slower population growth rate in the southern counties of the nine county Bay Region.

variables, to forecast U.S. enplaned passengers. The U. S. forecast is than distributed over the states, and the forecast for each state is distributed to individual airports. These forecasts are then adjusted according to state population, income and tower forecasts. Finally, information regarding average aircraft size, the carriers serving the airport, markets served and the future fleet of the carriers is used to test the internal consistency of the forecasts.

The ATA produces both a U. S. passenger forecast and a passenger forecast for individual airports. The ATA methodology is very similar to the methodology used by the FAA.

(2) Forecast Elements Required for Environmental Analysis

This environmental study was concerned with the following areas:

- Aircraft noise
- Access
- Air quality
- Other environmental concerns, such as water quality, wildlife, etc.

Forecasts were needed to support analysis of impact in each of these areas. For analysis of aircraft noise, it was necessary to have forecasts of aircraft operations, including types of aircraft, their trip length, and the flight tracks they would use on arrival and departure. For air

quality analysis, it was necessary to have forecasts of aircraft operations, as well as forecasts of automobile activity in the vicinity of the airport. The part of the automobile activity due to the airport was based on forecasts of O&D passenger activity.

Access analysis required forecasts of both on-airport and off-airport vehicular activity. Again, part of this forecast was based on forecasts of passenger activity. Analysis of other areas of environmental concern required, to some degree, a similar set of forecasts.

While much of this information was available from previous studies, some of it was not available in enough detail to support the analysis required in this study. Moreover, for reasons that will be discussed later, it was felt that some of the existing forecasts were subject to change. It was crucial to this study to pinpoint the year at which a certain level of activity would be reached. This is because of events external to the airport that are expected to follow a specific time schedule. Foremost among these are:

- Federal programs for aircraft and automobile engine emission reductions
- Federal programs for aircraft noise reduction
- The rate of growth of off-airport vehicular traffic

The sections that follow describe the process of developing the forecasts used in this study. Basically, the methodology was straightforward. Previous projections of passenger activity were reviewed in light of recent developments in the air transportation industry and the nation's economy. Based on this analysis, a preferred forecast was selected. Then, using the passenger forecast as a base, a number of projections were developed for aircraft operations. These projections were based on analysis of load factors, aircraft seating capacities, and current air carrier operating policies. From among these projections a preferred operations forecast was selected.

3. AIR PASSENGER FORECASTS

As discussed earlier, passenger forecasts for SFIA have been prepared by a number of agencies in recent years. In some respects, these forecasts reflect similar perceptions of the future among the various agencies. For example, there is fairly widespread agreement that SFIA will reach a level of 31,000,000 passengers (on and off) prior to 1990.

In other respects, however, the forecasts reflect a divergence of views about the future. Exhibit A-2 graphically depicts the more recently prepared forecasts discussed earlier.[3/] They are as follows:

3/ Exhibit A-2, like Exhibit A-1, presents the forecasts in terms of on and off (enplaning and deplaning) passengers, as they were originally presented when developed. To convert to in and out (total passengers) these figures should be increased by seven percent.

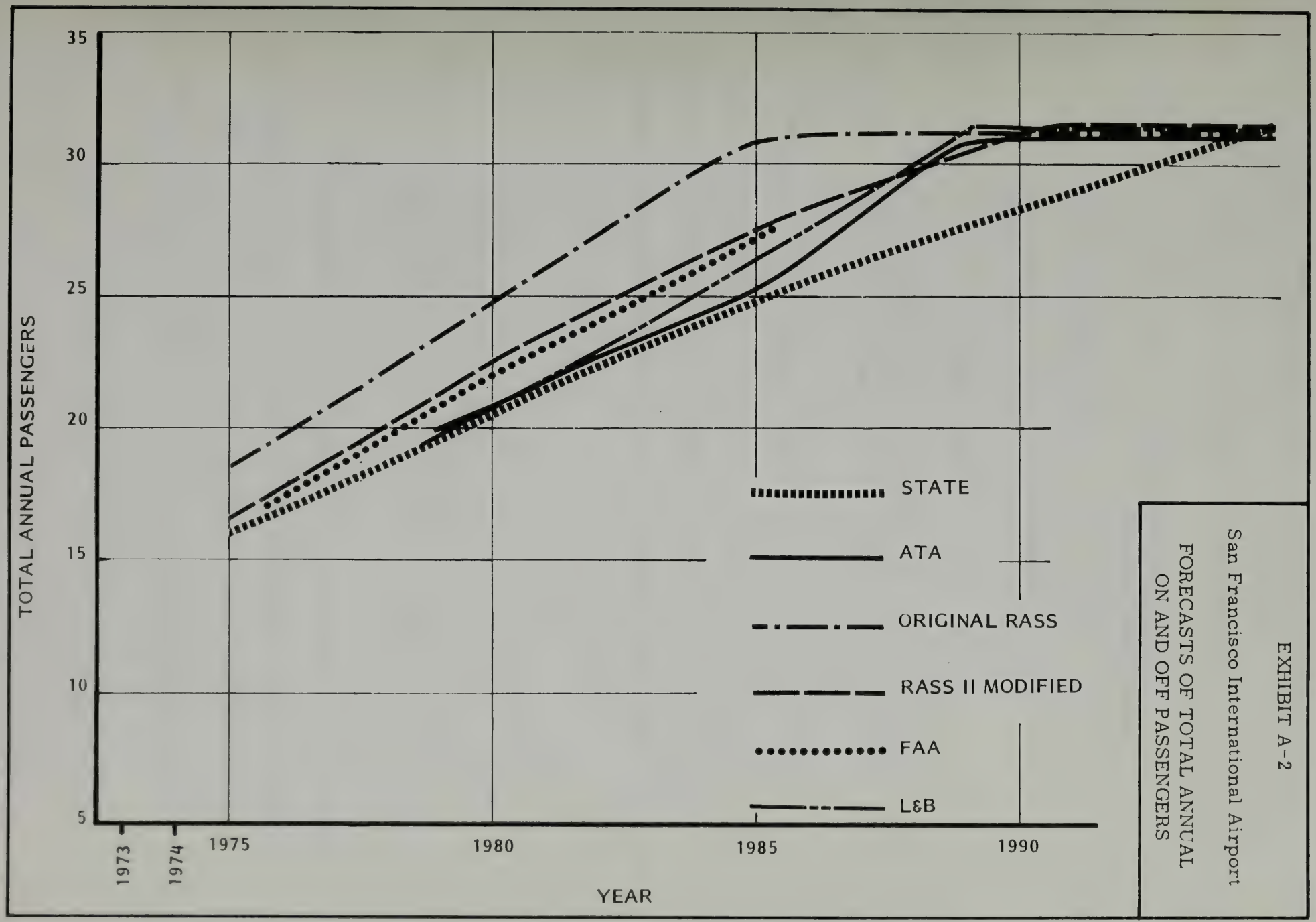


EXHIBIT A-2

San Francisco International Airport

FORECASTS OF TOTAL ANNUAL ON AND OFF PASSENGERS

- The California Department of Transportation forecast, prepared in 1974.

- The Air Transport Association's preliminary 1975 forecast.

- The original RASS forecast, prepared in 1972, which was used in the previous Environmental Impact Report published by the City of San Francisco Department of Planning in August, 1973.

- The modified RASS II forecast, released in December, 1974.

- FAA's 1975 Terminal Area Forecast.

- A forecast developed during this study by Landrum & Brown, based on regression analysis with per capita personal income and average fare per passenger mile.

It can be seen from the exhibit that there are variations of as much as ten years in these forecasts. The reasons for these variations are numerous. However, a number of recent trends have emerged that help explain these variations, and more importantly, led to the need for a re-evaluation of forecasts in this study. For example:

- The high growth rates of the mid-sixties are no longer evident. Hence, forecasts that were based on these growth rates have tended to prove too high.

- Population projections are lower. The impact of this trend would be to lower passenger forecasts.

SFIA management's current forecast of air passengers draws on the best thinking of all the agencies who have been involved in preparing forecasts for the airport. Moreover, this forecast reflects very recent national trends and events that will impact on future aviation demands. This forecast is based

on the modified RASS II forecast, which was announced on December 20, 1974. As shown in Exhibit A-2, the following levels of activity, expressed in terms of in and out passengers are used as the basis for all analyses in this study.

- 1974--17,400,000 passengers
- 1982--26,200,000 passengers
- 1990--33,300,000 passengers

The modified RASS II forecast was selected as the basis for this study for a number of reasons. First, as noted earlier, it reflects the best thinking of all parties involved in recent studies of growth at SFIA. Secondly, as can be seen in Exhibit A-2, all forecasts (except the original one by RASS) are tightly grouped, with the modified RASS forecast effectively serving as an upper bound. Using this upper bound for environmental analysis therefore constitutes a kind of "worst case" evaluation. Should one of the other forecasts prove more accurate, many of the problems expected will not be as severe. Finally, the current forecast projects lower growth rates than previously envisioned (just three percent per year). This fact has some distinct advantages:

- Because growth is not now expected to be as rapid as previously thought, the community has more time to solve upcoming saturation problems. The ultimate capacity of the airport (felt to be 33 million passengers in and out) is not expected to be reached until 1990. This leaves a period of 15 years within which alternate modes of transportation can be developed.

- If the implementation plan for the proposed expansion program is scheduled for completion in 1984-1985, the capacity of the terminal area will be above the demand for about five years. In terms of service to the flying public, this is a definite benefit.

* * * * * * * * * *

Once passenger forecasts had been developed, it was possible to determine the levels of aircraft operations needed to serve these passengers. This is described below.

4. FORECASTS OF OPERATIONS AND FLEET MIX

There were two major reasons why operations forecasts had to be developed as a part of this study:

- The RASS II modified forecast had no associated operations forecast, and none was expected before this study was to be completed.
- There was reason to believe that the assumptions underlying older operations forecasts were no longer valid.

The general procedure for forecasting air carrier operations is to make assumptions about future load factors (passengers on board divided by total seats available) and aircraft size, or seating capacity. These figures, used in conjunction with a passenger forecast, will produce an estimate of the number of operations expected.

Since 1970, there has been a general concensus that wide-bodied aircraft are going to dominate the air carrier fleet, and that average aircraft size would grow much more rapidly than would load factors. Recently, however, the rising cost of fuel has caused a shift in this thinking. Beginning in late 1973, air carriers began to suffer severe erosion of profits because

of the high cost of fuel, and mounted a concentrated effort to increase load factors--and therefore profits. This goal was sought through two tactics:

- Reduction in service frequencies
- Increased utilization of smaller aircraft.

It is now a general concensus that aircraft such as the B-747 are not as attractive as they once were thought to be. More likely, stretch versions of the B-727, DC-10 and L-1011 and perhaps a shorter version of the B-747 will dominate the air carrier fleet mix in the foreseeable future.

In terms of forecasting, these events have tended to invalidate many previous assumptions about load factors and average seating capacities. In general, load factors are growing much more rapidly than previously anticipated; while average aircraft size is not. Because of this, it was necessary to re-evaluate the forecasts for aircraft operations at SFIA.

The forecasts developed in this study reflect SFIA management's recognition of recent trends already visible at many airports. The following two sections describe the analysis leading to the operations forecasts used in this study and the mix of aircraft types expected in the future.

(1) Development of Average Seats and Load Factor Assumptions

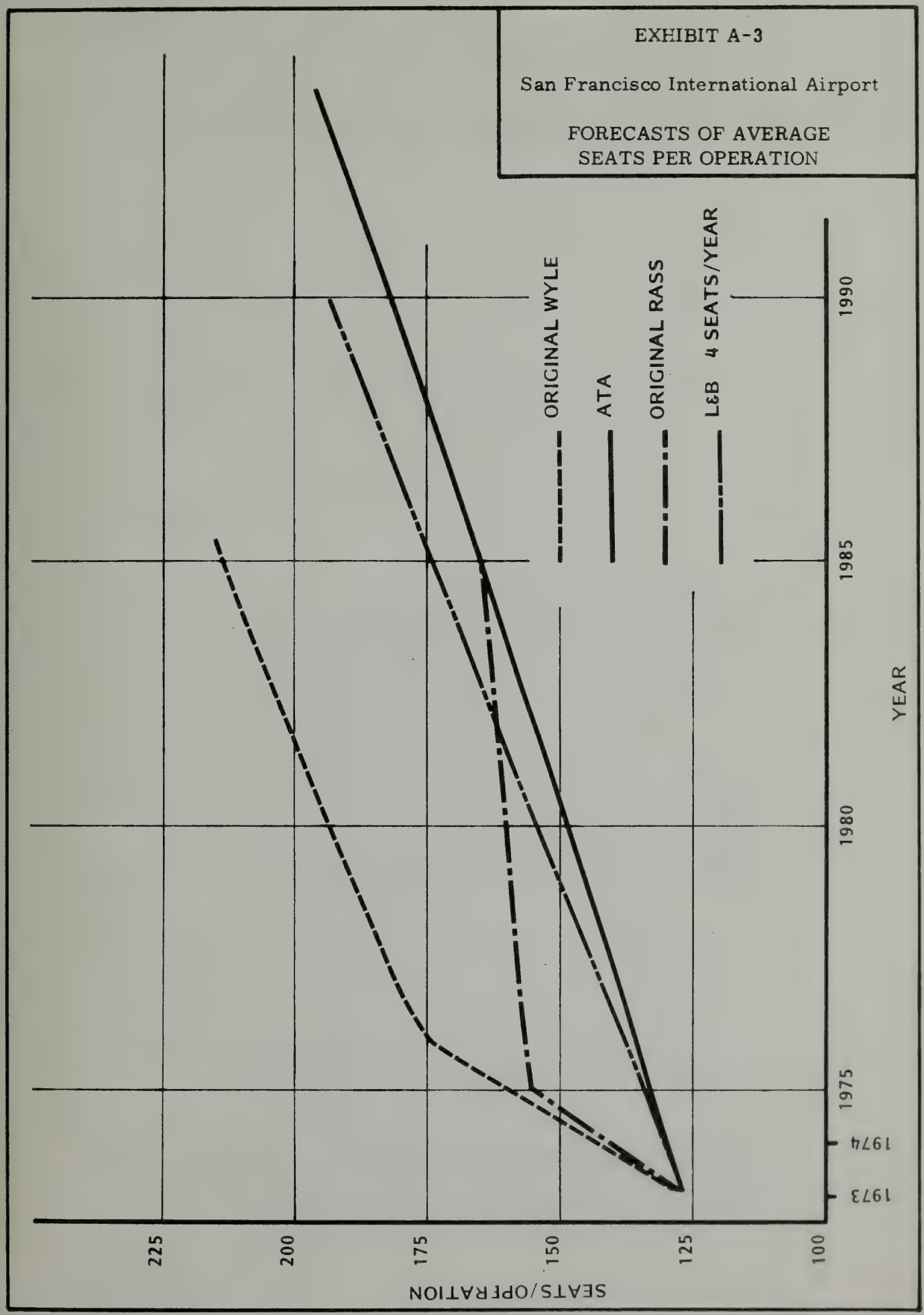
Exhibit A-3 shows four forecasts of average seats per operation for SFIA. They are based on the following:

- The fleet mix used by Wyle Laboratories in the noise analysis for the previous environmental study (6) by the City Planning Department.

EXHIBIT A-3

San Francisco International Airport

FORECASTS OF AVERAGE SEATS PER OPERATION



- The fleet mix from the original RASS study.
- ATA's forecast for SFIA, showing a growth of about three seats per year.
- An assumed growth of four seats per year.

These forecasts are based on growth from a 1973 level of 126.4 seats per operation, derived as shown in Exhibit A-4. (The year 1973 was chosen as the basis for this analysis because it was the most recent year for which a complete data set was available.)

The four seats per year growth rate was chosen for the following reasons:

- A four seat per year increase in average seats per departure, when translated into the rate of change over time for various aircraft type percentages, produces a fleet mix change that is realistic and compatible with the historic conversion rate of aircraft.
- Historically, average aircraft size has grown gradually, not dramatically. In developing projections of this sort, it must be remembered that the total aircraft fleet must be considered, and that older aircraft are phased out of the system on a gradual basis.
- The Wyle fleet and the original RASS fleet were felt to grow too rapidly, especially in the early years.
- The ATA forecast growth of three seats per year was felt to be too conservative, compared to historic rates in the neighborhood of five seats per year.
- As discussed later in this appendix, analysis of San Francisco's markets provides support for the conclusion that four seats per year is a realistic growth rate.

EXHIBIT A-4

San Francisco International Airport

DERIVATION OF 1973 AVERAGE
SEATS PER OPERATION

Type of Service	Operations	Total Seats	Average Seats Per Operation
Interstate 1/	215,858	27,285,726	126.4
Intrastate 2/	39,272	4,767,620	121.3
International Flag 2/	5,112	845,424	165.4
Totals	260,242	32,898,770	126.4

Sources:

1/ CAB statistics

2/ Management Records and the Official Airline Guide.

Load factor analysis was accomplished in a similar manner, as depicted in Exhibit A-5. (The ATA load factor projection was not finalized at the time the analysis was done, and only a 56 percent figure was available, for 1990, without a specific growth rate.) It should be noted that the load factors shown in Exhibit A-5 are boarding load factors, defined as enplanements divided by total seats available.

The boarding load factors selected for use in this study are 50 percent in 1982 and 55 percent in 1990, based on the following reasoning:

- A 55 percent boarding load factor results in an on-board load factor of approximately 60 percent for SFIA, which is close to industry standards for system wide load factors.
- The original RASS projection for 65 percent in 1985 is unrealistically high and would produce severe deterioration of service.
- The load factors as derived from the Wyle analysis are unrealistically low, considering current trends.
- Close correspondence with the ATA figure for 1990 tends to verify the rate of growth selected.

These figures formed the basis for development of operations and fleet mix forecasts, described below.

EXHIBIT A-5

San Francisco International Airport

FORECASTS OF ANNUAL BOARDING LOAD FACTOR

(2) Forecasts of Operations

Exhibit A-6 summarizes the various figures used in the analysis of load factors, aircraft sizes and operations. Operations figures in the exhibit were derived from these data as follows:

- seats x load factors = passengers/operation
- total passengers ÷ passengers/operation = operations

Note that the above computations produce only domestic scheduled and international passenger and cargo operations, and do not include general aviation, military, third level and helicopter operations. It was decided to keep these activities at their 1973 levels. This was done for two reasons:

- At airports the size of SFIA, general aviation and military activity tend to level off at about 50,000 operations per year. For example, the SFIA 1973 level for these two categories was 46,510; while at Chicago-O'Hare International Airport, the 1973 figure was 46,942.
- Third level and helicopter activity are closely linked to air carrier activity. Therefore, it is reasonable to assume that their activity will grow as air carrier activity grows. Since no substantial growth is forecast for carrier operations, none was assumed for third level and helicopter operations. The 1973 level of 29,730 operations was assumed.

EXHIBIT A-6

San Francisco International Airport

SUMMARY OF PASSENGER AND OPERATIONS FORECASTS

Year	Total Passengers (Millions)	Passengers Per Operation	Load Factor Percentage		Average Seats	Operations	Notes
			Boarding	On Board			
1973	15.9	61.1	45.4	48.4	126	260,242	BASELINE--without helicopter or third level passengers and operations
1975	20.4	83	49	54	155	247,400	ORIGINAL RASS--without helicopter and third level operations
1980	24.7	100	58	63	160	246,600	
1985	33.3	116	65	69	167	286,000	
1976	20.4	68	37	39	175	300,000	WYLE LABS--without helicopter and third level operations
1981	24.7	80	41	42	190	310,000	
1986	33.3	107	47	50	214	310,000	
1982	25.3	94	50	54	175	269,700	NEW--with Wyle fleet mix shifted in time 1/ and assumed load factor
1990	32.8	112	55	59	190	291,900	
1982	25.3	87	50	54	162	291,400	PREFERRED--based on 4 seats per year growth and assumed load factors
1990	32.8	115	55	59	194	285,100	

1/ Original Wyle fleet mix was prepared by R. Dixon Speas & Associates, for 1976 (giving 175 seats) and 1981 (giving 190 seats).

Therefore, forecast total annual operations for SFIA are as follows:

- 1982--367,640
- 1990--361,340

(3) Forecasts of Fleet Mix

Fleet mix is the relative number of different types of aircraft operating at an airport. This is a critical data base element, as it will have a marked impact on airfield capacity and delay, noise emission and air quality.

Of all the various sources for existing fleet mix information, it was felt that the flight strips from the air traffic control tower were best. FAA flight strips were chosen because this is the only source of data on every departure (except helicopters) from the airport, and contains information on aircraft type, departure time, destination and flight pattern used.

Based on analysis of these tapes and an adjustment to account for helicopters, each departure was assigned to one of 14 aircraft classification codes, as shown in Exhibit A-7. It should be noted that:

- The existing (1974) fleet mix is based on three days of representative activity.

EXHIBIT A-7

San Francisco International Airport

AIRCRAFT FLEET MIX FORECAST

Code	Description	Typical Aircraft	1974		1982		1990	
			Percent	Total Operations	Percent	Total Operations	Percent	Total Operations
1	Four Engine Turbo Jet	B-707-120, 320; B-720; DC-8-20, 30; CV-880	3.24	10,823	1.17	6,993	1.19	4,305
2	Four Engine Turbo Fan & Four Engine "Stretch Fan"	B-707-120B, 320B; B-720B; DC-8-40, 50, 61, 62, 63	19.95	66,623	11.70	43,010	7.50	26,628
3	Three Engine Turbo Fan	B-727-100, 100C/QC	24.93	83,274	13.89	51,082	12.59	44,732
4	Three Engine "Stretch" Fan	B-727-200	(Combined with Code 3)					
5	Two Engine Turbo Fan	B-737; DC-9; BAC-111	19.28	64,414	22.81	83,864	20.89	74,211
6	Four Engine HBPR Fan	B-747	4.29	14,326	6.90	25,381	9.48	33,670
7	Two & Three Engine HBPR Fan	DC-10; L-1011; A-300B	4.19	14,016	22.05	81,070	27.96	99,330
8	Supersonic Transport	Concorde; TU-144	--	--	--	--	0.63	2,224
9	General Aviation Jet	Jetstar, Lear	0.74	2,493	0.68	2,493	0.69	2,493
10	Four Engine Trubo Prop	L-188; L-100; DC-6,7	1.75	5,830	1.35	4,965	1.37	4,965
11	Two Engine Turbo Prop, over 12,500 lbs.	CV-580, FH-227, M-404	2.74	9,149	1.22	4,488	1.24	4,488
12	Twin Engine Piston Prop Under 12,500 lbs.	310, Baron, Aero-commander 500, 421	8.28	27,669	7.59	**27,669**	7.62	27,669
13	Single Engine Piston Prop; STOL	172; Bonanza	3.41	11,383	3.10	11,383	3.13	11,383
14	Helicopter	S-61	7.18	24,000	6.87	25,242	7.60	25,242

- General aviation aircraft comprise aircraft classes 9, 12, and 13.

- Class 10 aircraft are comprised almost entirely of military aircraft (with the exception of a small number of all-cargo aircraft).

To develop fleet mixes for the 1982 and 1990 demand conditions, all previous fleet mix forecasts were carefully reviewed. Because of the major effort required to develop a new fleet mix, it was concluded that past work should be used to the maximum extent possible. It was noted that the fleet mix developed for Wyle Labs by R. Dixon Speas and Associates corresponded closely with the preferred forecast developed in this study--except for the year of occurrence. Specifically, the Speas fleet mix for 1976 produced 175 average seats per operation, compared with a preferred 1982 level of 164; and the 1981 Speas fleet mix resulted in 190 seats, compared to a preferred 1990 level of 194. Given that passenger forecasts had been shifted by approximately five years, it was considered reasonable to adopt a corresponding shift in the fleet mix forecast. In conversations with Speas personnel it was generally agreed that such an assumption would be valid. Moreover, it was concluded that the Speas work was based on in-depth analysis, and that to conduct a similar analysis in this study would be a duplication of the effort.

One final check was made before this assumption was adopted. The markets served by the carriers in San Francisco were examined

to determine the estimated future passenger levels that would justify wide-body operations on a regular basis. This analysis indicated that 22 percent of operations in 1982 would be by wide-bodied aircraft. Since this analysis did not take into account points beyond these cities (that might justify a wide body flight on another leg of the same route), it was concluded that the 22 percent level was probably low. Therefore, the Speas 1976 fleet mix, which gives 36 percent wide body activity, was assumed to be appropriate for 1982 analysis in this study. The fleet mixes shown in Exhibit A-7 for 1982 and 1990 are the Speas fleet mixes for 1976 and 1981, respectively.

5. THE "DO NOTHING" FORECAST

An integral part of this study was an evaluation of the conditions that would occur if no development action were undertaken--called the "do nothing" condition. To properly assess the impacts under this condition, it was necessary to consider what effect there would be on activity at the airport if the proposed program were not implemented.

The first point of consideration in this question lies in the effect on the level of aircraft activity. The proposed expansion program is designed to accommodate expected increases in wide-bodied aircraft operating at SFIA. It might seem reasonable to assume that if the program were not implemented, it would deter the carriers from operating the desired number of wide-bodied aircraft at SFIA.

This is not likely to occur to an extent that would produce a measurable effect. There are two reasons for this:

- Air carrier requirements for scheduling aircraft to be in a given location at a given time have a considerably stronger bearing on the kinds of aircraft used at a given station than do the facilities available at that station.

- The air carriers have demonstrated that they will "make do" when faced with inadequate facilities or less than ideal conditions. Examples of this are Atlanta and Chicago, where there is a severe shortage of facilities. In spite of such disadvantages as extreme delays and severe degradation of service to passengers, the carriers have elected to "make do" rather than curtail their activities.

Consequently, it is unlikely that a decision not to implement the proposed program would affect the fleet (or numbers) of aircraft serving San Francisco. Moreover, in view of the fact that no airfield improvements that might boost capacity are contemplated, a "do nothing" decision would not affect airside delays--another possible deterrent. It should be noted that there would be an increase in ground delays to aircraft because of a shortage of adequate gates to service them. However, these delays would have little or no effect on the level of activity or its growth.

Another question to be considered is the impact of a "do nothing" decision on passenger activity. As the proposed program does not involve any major improvements to the airport access system, the "do nothing" case would not produce conditions that would not otherwise ensue. Therefore, access would

not be more of a deterrent to passenger activity in either case. As mentioned earlier, though, there would also be a deterioration (perhaps severe) in service to the passengers. This problem would manifest itself in a marked increase in congestion at the curb front, crowding within the terminal areas themselves and inconvenience in terms of access to the aircraft.

However, none of these factors have much of a bearing on passenger demand, which is instead very strongly based on local economics and the cost of travel. Professional travelers (businessmen) go because they must; and pleasure travelers give little thought to anything other than cost when deciding whether or not to fly.

In short, the analysis conducted in preparation of this EIAR was based on two fundamental truths about aviation in the United States:

- Airport facilities do not induce demand for air transportation services, communities do. Evidence is abundant throughout the history of U.S. aviation that airports are only economically viable when they are located in close proximity to a bona fide market for air transportation service. Evidence is also available demonstrating when airport facilities are built at great distances from an existing market (in the hope that new facilities will induce demand) such airports tend to be severely under utilized.

- Air carriers and air passengers have an unbelievably high tolerance for congestion and delay at airports. Again, there is abundant evidence throughout the U.S. to support the contention that deficient facilities are not an effective way to inhibit the growth of aviation demand at an airport.

Because there are three airports in the Bay Area, however, there remains the question of how much of the total demand should be accommodated at each airport. This question was answered in the RASS study, as described earlier. Consequently, it was not addressed in preparation of the EIAR. Rather, the issue was whether it is in the community's interest to accommodate the growing air transportation demand allocated to SFIA.

In summary, it was concluded that a "do-nothing" decision would not affect the character or volume of activity at San Francisco International Airport. The cause and effect characteristics are more a function of economic variables than facility availability. Consequently, the forecasts adopted for this condition were the same as those used to assess the impact of the proposed program.

6. PURPOSE AND SCOPE OF THE DEMAND/CAPACITY ANALYSIS

The purpose of a demand/capacity analysis is to identify those portions of either the airfield or terminal that are or will be deficient in terms of performing at an acceptable level of efficiency. A determination of the impact of operating with a demand below, at, or above capacity is made in quantifiable terms of hours of delay for the airfield or level of congestion for a terminal.

For this study an airfield demand/capacity analysis was necessary because annual hours of aircraft delay were required for input into the air quality assessment analysis. Similar analyses have been conducted in previous studies for San Francisco International Airport. However, because the aircraft operations and fleet mix forecasts were updated in this study, it was necessary to recalculate the delay data used for the air quality analysis.

Demand capacity analysis of the terminal area was not conducted. It was felt that the amount of study behind the proposed expansion plan was more than acceptable for the purposes of this environmental evaluation. Demand capacity analysis of the vehicular access system is described in Appendix C.

7. AIRFIELD DEMAND/CAPACITY ANALYSIS METHODOLOGY

The computational techniques used for this airfield capacity and delay analysis were developed for the FAA and have become standard techniques in the industry. They have been in the process of development since 1959, and have been published in handbooks and advisory circulars for use by airport planners in determining airfield requirements. (7,8)

Airfield capacity is expressed in terms of practical hourly capacity (PHOCAP) and practical annual capacity (PANCAP), and an associated annual delay (ANDE) at a particular level of demand. The capacity calculations incorporate reasonable and practical amounts of aircraft delay, as follows:

- Four minutes average delay for all visual flight rules (VFR) 4/ departures.
- One minute average delay for all VFR arrivals.
- Four minutes average delay for all instrument flight rules (IFR) 5/ arrivals and departures.

These delay levels were established during development of the computation techniques, and reflect the impact of high demands at peak periods. Even with such apparently low average delay levels, an average delay of four minutes can still result in a delay to any given aircraft from zero to twenty minutes. The computed, practical capacity is the level of operations at which these average delay levels are reached. These practical capacities can be exceeded but only at higher delay levels.

The capacity of an airport is affected by many variables. In particular, the Airport Capacity Handbook identifies the following elements as key capacity determinants:

- Airspace
- Weather conditions (meteorology)
- Runway operating configurations
  - Parallel
  - Intersecting
  - Terminal location

4/ VFR--When conditions of visibility and ceiling are greater than three miles and 1,000 feet, respectively.

5/ IFR--When conditions of visibility and ceiling are less than three miles or 1,000 feet, respectively.

. Physical properties of runways

- Length
- Runway service times
- Taxiway system

. Airport instrumentation

. Aircraft fleet mix

Each of these elements, as it relates to San Francisco International Airport, is discussed in detail in the following paragraphs.

(1) Airspace

The criteria used in the Airport Capacity Handbook require that airspace be defined as unrestricted, normal or highly restricted. At San Francisco International Airport, each runway has a set of Standard Instrument Departures (SID's) that use one or two common paths or allow departures to be fanned out in three or more directions. For this analysis, departures were defined as either highly restricted or normal, based on the above conditions. Exhibit A-8 presents the findings of that analysis.

(2) Meteorology

Meteorological conditions experienced at an airport affect runway utilization due to visibility and to prevailing wind directions. These conditions determine the directions in which operations may be conducted and the frequency of use for each airfield

EXHIBIT A-8

San Francisco International Airport

AIRSPACE DEFINITIONS

Departure Runway End	No. of Departure Paths	Airspace Definition
1R/1L	4	Normal
10R/10L	1	Highly Restricted
19R/19L	1	Highly Restricted
28R/28L	3	Normal

operating configuration. Normally, historic weather records detailing observations of wind direction, speed, ceiling and visibility are used to determine the approximate percentage of time a specific runway operating configuration can be used, based on allowable crosswind components.

In the case of San Francisco International Airport, the need for such an analysis was preempted by existing noise abatement procedures, which result in certain operating configurations being used predominantly. To establish operating configurations and relative utilization of these configurations, FAA Air Traffic Control Tower records detailing hourly numbers of operations and runways used for landings and departures were collected and analyzed. The results of that analysis are presented in Exhibit A-9.

The annual percentages of VFR and IFR weather (95 and 5 percent, respectively) were determined from data presented in previous airfield capacity analysis reports for San Francisco International Airport. (9)

(3) Runway Operating Configurations

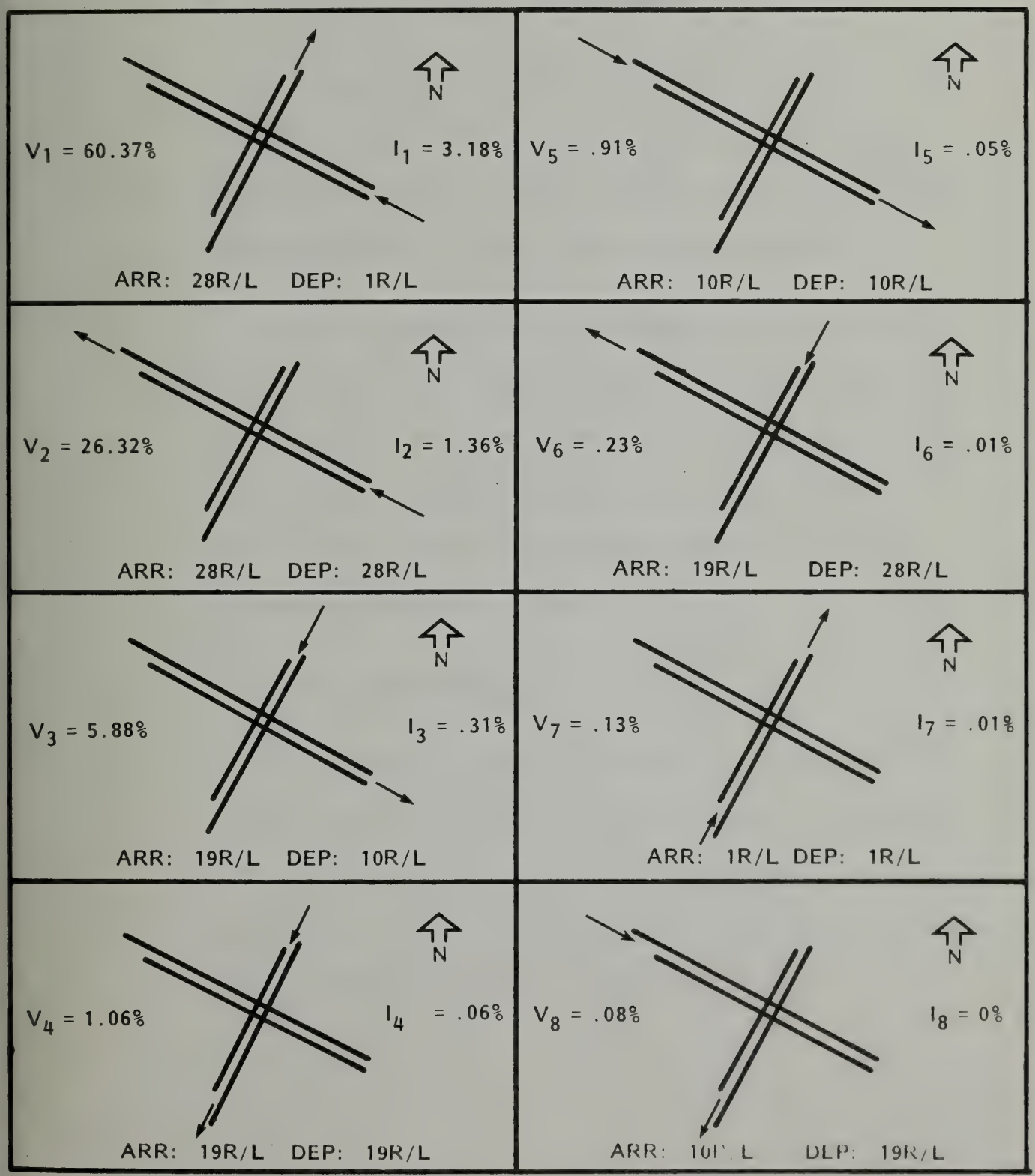
The hourly capacities of the runway configurations presented in Exhibit A-9 were evaluated based on parallel runway separation distances, runway intersection locations and the location of the

EXHIBIT A-9

San Francisco International Airport

OPERATING CONFIGURATIONS/PERCENT UTILIZATION

VISUAL FLIGHT RULE CONDITIONS (V)
INSTRUMENT FLIGHT RULE CONDITIONS (I)



terminal in relation to active runway ends. The configuration data utilized in the determination of the capacity of each configuration are presented in Exhibit A-9, which was discussed earlier.

(4) Physical Properties of the Runways

The length of a runway determines its adequacy to accomodate various types of aircraft for landing or takeoff. Each runway at San Francisco International Airport will generally satisfy the runway length requirements of all the aircraft using the airport.

For the purposes of the airport capacity determination, a set of runway ratings, or runway service times, expressed as the average number of seconds a landing aircraft will occupy a runway, are used to reflect the impact of these runway occupancy times on airport capacity. Exhibit A-10 presents the runway ratings for San Francisco International Airport.

(5) Airport Instrumentation

The availability, types and locations of navigational aids (NAVAIDS) on and in the vicinity of the airport affect the capacity and utilization of an airport in both visual and instrument weather conditions. An inventory of the existing NAVAIDS at San Francisco International Airport is presented in Exhibit A-11.

EXHIBIT A-10

San Francisco International Airport

RUNWAY RATINGS

Runway End	Runway Rating (in Seconds)
1R	49
1L	42
10R	48
10L	51
19R	44
19L	45
28R	45
28L	47

EXHIBIT A-11

San Francisco International Airport

INVENTORY OF NAVIGATIONAL AIDS

Runway End	Type of Instrumentation (Approaches)
1	Radar
10R	ILS Backcourse, VOR
10L	VOR
19R	VOR
19L	ILS, VOR, NDB
28R	VOR 1/
28L	ILS, CAT II ILS, VOR, NDB

Other Information: Group 1 Terminal Control Area, VOR on Airport, Control Tower, Radar, Runway Lighting, Approach Lights, Runway 19L and 28L

Definitions:
CAT II ILS - Category II Weather Minimum ILS
ILS - Instrument Landing System
NDB - Non-Directional Beacon
VOR - Very High Frequency Omnidirectional Range

1/ FAA is currently installing a Category III ILS on runway 28-R. When this is completed, runway 28L will be designated as a Category I facility.

(6) Aircraft Fleet Mix

Aircraft fleet mix is discussed earlier in this appendix. For capacity analysis, aircraft types are grouped into six categories according to size and operational characteristics. Current and forecast operations mixes used for capacity analysis of San Francisco International Airport are presented in Exhibit A-12.

8. FINDINGS OF THE AIRFIELD DEMAND/CAPACITY ANALYSIS

The above inputs were used to determine the practical hourly capacity (PHOCAP) of each configuration, the practical annual capacity (PANCAP) of the airfield as it operates over the entire year and the annual delay (ANDE). The results of that analysis are presented in Exhibits A-13 and A-14.

9. AIRPORT FACILITY REQUIREMENTS

As noted at the beginning of this appendix, the primary purpose for the foregoing analysis was to support the environmental study of the proposed expansion plan. However, because this analysis produced a change in the aviation demand forecasts, it is worthwhile to consider the possible impacts this change could have on airport facility requirements. The paragraphs that follow summarize SFIA management's thinking in this regard.

(1) The Effect of Reduced Passenger Growth

Passenger growth is not now expected to occur at as rapid a rate as thought in earlier planning studies for SFIA. The real

EXHIBIT A-12

San Francisco International Airport

AIRCRAFT CLASSIFICATIONS

Aircraft Class	Aircraft Description	Typical Aircraft	Percent of Total Fleet		
			1974	1982	1990
AA	Heavy jet aircraft of gross weight in excess of 300,000 pounds.	B-747, L-1011, DC-10, DC 8, B-707-320	22.3	38.9	45.2
A	Other large four engine jets.	B-707-120, Convair 990, 880	15.5	8.2	5.7
B	Two and three engine jets and most heavy prop transports.	B-727, DC 9, B-737, Convair 580	47.8	39.5	35.4
C	Medium twin engine aircraft and most business jets.	F-27, Beech 99 and Kingair, Lear 24, 25	2.9	2.0	2.1
D	Light twin and heavy single engine aircraft.	Beech Bonanza, Piper Aztec	14.5	11.4	11.6
E	Light single engine aircraft.	Cessna 150-210, Piper Cherokee			

EXHIBIT A-13

San Francisco International Airport

HOURLY CAPACITY DATA

Configuration		1974 HDC 1/	1974 HAC 2/	1982 HDC	1982 HAC	1990 HDC	1990 HAC
V_1		32	32	28	28	26	26
	I_1	22	32	20	28	19	26
V_2		46	32	42	28	40	26
	I_2	29	36	23	28	23	26
V_3		32	32	28	28	26	26
	I_3	22	32	20	28	19	26
V_4		34	32	31	28	30	26
	I_4	20	32	17	28	17	26
V_5		45	32	42	28	40	26
	I_5	26	32	23	28	23	26
V_6		32	32	28	28	26	26
	I_6	20	31	20	28	19	26
V_7		45	32	42	28	40	26
	I_7	26	32	23	28	23	26
V_8		32	32	28	28	26	26
	I_8	22	32	20	28	19	26

1/ HDC is Hourly Departure Capacity.

2/ HAC is Hourly Arrival Capacity.

EXHIBIT A-14

San Francisco International Airport

ANNUAL CAPACITY AND DELAY

Year	PANCAP	Annual 1/ Demand	ANDE (Hours)		
			Arrival	Departure	Total
1974	393,000	310,000	3,565	3,465	7,030
1982	346,600	342,398	8,166	7,288	15,454
1990	321,850	336,098	10,464	9,025	19,989

1/ Excludes helicopter Operations.

impact of this change, however, should be thought of in terms of time rather than numbers of passengers because the same passenger volumes will be reached -- only at a later date. As noted earlier in this appendix there are two distinct advantages to this:

- Because growth is not now expected to be as rapid as previously thought, the community has more time to solve upcoming saturation problems. The ultimate capacity of the airport (felt to be 33 million passengers in and out) is not expected to be reached until 1990. This leaves a period of 15 years within which alternate transportation services can be developed.

- If the implementation plan for the proposed expansion program is scheduled for completion in 1984-1985, the capacity of the terminal area will be above the demand for about five years. In terms of service to the flying public, this is a definite benefit.

Accordingly, it would not be appropriate to modify the expansion program based on the findings of this study as they relate to passenger demand.

(2) The Effect of Forecast Operations on Airfield Facility Requirements

As demonstrated in Exhibit A-14, SFIA will be operating at somewhat above its airfield capacity by 1990, producing slightly under 20,000 hours of annual delay in 1990. This translates to

just over 3.5 minutes of delay per operation. While such delays might seem high, they are in actuality quite acceptable when compared to delays suffered at most of the nation's larger airports.

Further, it should be noted that this over capacity situation is only temporary. Beyond 1990 the aircraft fleet at SFIA will become more and more dominated by wide-bodied aircraft. Because of these increased numbers of wide-body aircraft, separation requirements between wide-body and conventional aircraft will be of less impact on capacity. Previous studies (9) have shown that, for example, when the fleet is composed of 60 percent wide-body, the airfield capacity of SFIA will not be exceeded by demand.

Consequently, based on the findings of this study, it would not be appropriate in this study to consider any major changes to the airfield at SFIA.

(3) The Effect of Changing Fleet Mix Forecasts

As with the passenger forecast changes, adjustments to the SFIA fleet mix forecast should also be considered in terms of time. In other words, the community has more time to solve the upcoming saturation problems because the wide-bodied influx will not be as rapid as originally thought.

* * * * *

This appendix has described the investigations conducted in this study regarding aviation demand and capacity at SFIA. The principal results of this study are as follows:

- Previous forecasts, which estimated an ultimate level of 33 million (in and out) passengers at SFIA, have been reaffirmed.

- The analysis provided the quantitative description of the future years (until the ultimate level is reached) that is needed to support the environmental impact analysis.

The data base developed in the analysis described in this appendix is referenced throughout the remainder of this report.

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1. Aviation Forecast, Bay Area Study of Aviation Requirements, System Analysis Research Corp., May, 1970.

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7. Airport Capacity Handbook, Airborne Instruments Laboratory, (AIL), June, 1969.

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9. Airport and Airspace Capacity Analysis, Bay Area Study of Aviation Requirements, R. Dixon Speas Associates, May, 1970, Pg. 4-14.

APPENDIX B

NOISE IMPACT

APPENDIX B

NOISE IMPACT

Large scale introduction of commerical jet aircraft has intensified noise effects experienced by communities around airports. Stimulated by public reaction, noise impact investigations have resulted in development of techniques for evaluating and helping to relieve community noise impact. In addition, federal and state legislation has contributed to lessening noise impact due to aircraft operations.

1. INTRODUCTION

The purpose of this appendix is to describe the noise impact of a terminal expansion project at San Francisco International Airport. Two methodologies were used in the analysis: CNEL (Community Noise Equivalent Level) and ASDS (Aircraft Sound Description System).

A number of conditions were analyzed in order to understand more fully the noise impact. For each methodology (CNEL and ASDS), the noise impact was evaluated at:

- 1974 existing conditions
- 1982 conditions
- 1990 conditions

In addition, the effect of seasonal wind shifts was evaluated for each of the three conditions above.

The remainder of this appendix is organized into four major topics, entitled as follows:

- General Discussion of Noise Impact Analysis
- Description of Methodology
- Input Data
- Impact Assessment

2. GENERAL DISCUSSION OF NOISE IMPACT ANALYSIS

Noise impact analysis is at best a complicated problem. Because of the varied manner in which people react to noise, objective methodologies are difficult to develop and it is even more difficult to obtain a consensus as to their effectiveness.

The Federal government has recognized the noise problem and has passed legislation that deals with controlling and reducing noise impact. (1) (2) (3) (4) (5) (6).[1/] Interpretation of the legislation has been performed by the Environmental Protection Agency (7). Various state and local governments have enacted noise legislation and resolutions (8) (9), and the California noise legislation is probably the most noteworthy and relevant to this analysis. Finally, non-governmental organizations have adopted noise rules and regulations that deal with helping to relieve the noise problem (10) (11) (12). The paragraphs that follow describe the analytical tools used in implementation of some of these regulations.

1/ Numbers in parenthesis refer to the reference numbers listed in the bibliography at the end of Appendix B.

(1) Units of Noise Measurement

The human ear can react to sound pressure ranging from 0.0000000029 pounds per square inch (the threshold of hearing) to over 0.0029 pounds per square inch (the threshold of pain) -- a pressure level one million times greater. The price for this versatility is a decrease in sensitivity as amplitude increases. In other words, the ear cannot detect small changes in high pressure level (loud) noises as easily as it can detect small changes in low pressure level (soft) noises.

This response is best characterized as logarithmic rather than linear. A linear scale for the sound pressure range above would run from one to one million; while on a base 10 logarithmic scale, the values would range from one to six. The actual noise measuring scale used, in units called Bels, is based on sound energy, which is proportional to sound pressure squared. Finally, for convenience, each Bel is divided into ten smaller units, which results in the familiar noise unit in decibels (dB).

Because the decibel scale is logarithmic, sound variations produce sometimes unexpected changes in the units of measurement. For example, doubling the noise energy of a source results in a rise of only 3dB, and increasing the noise energy tenfold causes only a 10dB increase. Subjectively, however, this 10dB increase would be perceived as a doubling of the noise level.

Because human response to noise is the most frequent area of concern, one of the more common units of measure considers only that part of the noise heard by the human ear. This is called an "A-weighted" measure, and considers only the sound between 16 and 20,000 cycles per second -- the frequencies within the range of human hearing. Measurements of such noise are usually expressed as dBA.

(2) Noise Descriptors

There are two general methods available to describe noise impact resulting from aircraft operations. The first involves those descriptors that characterize a single event such as an aircraft takeoff or landing. The second involves those descriptors that characterize the noise impact of numerous single events (e.g., takeoffs or landings) over various time frames. Single event noise impact descriptors are generally considered inadequate to describe completely the noise environment around airports. Noise descriptors that characterize the noise environment as a set of repeated events are therefore more widely accepted and used.

Four noise descriptor systems have been used in California to describe the noise environment in the vicinity of an airport:

- CNR (Composite Noise Rating)
- NEF (Noise Exposure Forecast)
- CNEL (Community Noise Equivalent Level)
- ASDS (Aircraft Sound Description System)

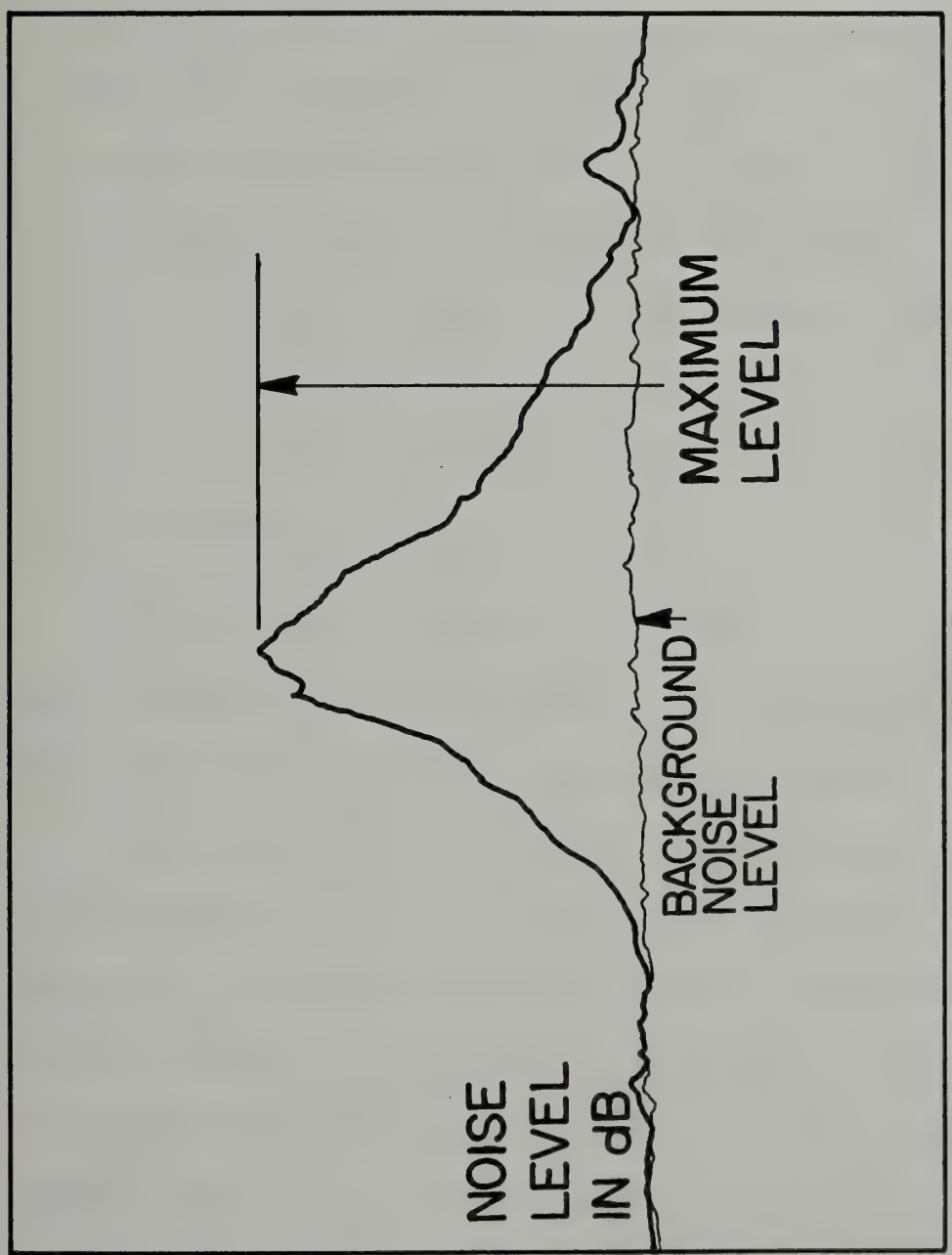
The first three systems (CNR, NEF, and CNEL) are similar in nature, but the ASDS descriptor is quite different in its approach to analyzing noise impact. The common characteristic of these four noise descriptor systems is that all are multi-event noise systems.

To better understand the four methodologies, a single noise event should be examined. The individual noise events of most concern are generated by aircraft "flyovers", during takeoffs and landings. The typical flyover noise signal may be characterized in time as a "haystack" shaped graph (noise level vs. time) that rises from a lower ambient noise level and increases to a maximum over a period of seconds and then decreases to merge once more with the background noise. This is depicted in Exhibit B-1. The flyover signal may be described in terms of maximum level reached during the flyover or in terms of the integration of the signal over time (i.e., including the effects of signal duration as well as maximum level). Common measures for the maximum flyover noise signal are the perceived noise level (PNL) expressed in perceived noise decibels (PNdB), and the A-weighted sound level expressed in dBA. The "integrated" flyover noise measures of most interest include the effective perceived noise level (EPNL), employed particularly in aircraft noise certification procedures; and the single event noise exposure level (SENEL), an integration of the A-level over time.

EXHIBIT B-1

San Francisco International Airport

TYPICAL FLYOVER NOISE SIGNAL



The Composite Noise Rating (CNR) System, developed by Bolt, Beranek, and Newman was an early method for predicting average community response to aircraft noise and for developing compatible land use plans in the vicinity of airports. It made use of empirically derived forecasts of noise exposure at airports, and related the estimated noise exposure to the expected response of residential communities. Contours of equal noise impact levels are plotted on a map of the airport and surrounding area. The CNR method included both a sound intensity measurement and a spectrum shape factor; and used weighted values related to human hearing, with greater weight given to high pressure level (loud) noises. The unit of measure was PNdB (perceived noise decibels), and the scale was logarithmic like the decibel scale for sound. Sounds of equal perceived noise levels were judged equally noisy under controlled subjective testing.

The Noise Exposure Forecast method (NEF) was also developed by Bolt, Beranek, and Newman to refine and augment the CNR method and to accommodate the need for a noise exposure descripor that would serve as a more flexible analytical tool in evaluating alternative development plans and noise abatement strategies, rather than community response. The NEF effective perceived noise level (EPNL) measurements, in EPNdB's, are a modification of the CNR perceived noise level measurements and include subjective correction factors to account for duration and pure tone components. Noise with significant pure tone

components is subjectively judged louder than sounds of the same intensity without pure tones. Similarly, as the duration of the sound increases, the subjective noise level will increase. The NEF methodology is useful in land use analysis and comparative evaluation of alternative airport development plans; but is not designed for predicting individual response to aircraft noise.

The Community Noise Equivalent Level (CNEL) technique originated with a 1970 California law (8). This law requires airports that have been classified as having noise problems to set up a noise monitoring system in the airport vicinity. Noise is to be measured in decibels using the A-weighted scale. CNEL is, effectively, the time-averaged noise level at the measuring point, weighted by time of day.

There are a great many similarities between CNEL and NEF, even though the former was developed to monitor noise and the latter to forecast community noise exposure. The two main differences are that CNEL uses dBA measurements and divides the day into three separate periods (day, evening and night) for weighting purposes; while NEF uses EPNdB and only two daily periods (day and night).

The Aircraft Sound Description System (ASDS) was developed for the FAA and was adopted effective July 1, 1974 as the method for developing, predicting, describing and interpreting noise impact of aircraft

operations in the vicinity of airports. The main objectives in developing the ASDS methodology were:

- Enchanced objectivity
- More understandable noise exposure index
- Land use interpretions in terms of ASDS contours.

The FAA has found that ASDS satisfied these objectives although there is debate within various government agencies as to its effectiveness as a land use planning tool.

ASDS permits quantification of noise impact in terms of the cumulative minutes of exposure (at various points on the ground) to noise levels above a preselected threshold value. The A-weighted noise level is used and the preselected threshold value is 85 dBA.

The similarities and differences of the four noise descriptors discussed above can be readily identified:

- Different measures of sound level:
  - CNR, PNdB
  - NEF, EPNdB
  - CNEL, dBA
  - ASDS, dBA
- Different weighting factors for time of day of operations:
  - CNR, day/night
  - NEF, day/night
  - CNEL, day/evening/night
  - ASDS, none

. Availability of land use guidelines:

- CNR - yes
- NEF - yes
- CNEL - yes
- ASDS - none at present time

Each noise descriptor has its own advantages and disadvantages in level of sophistication and ease of understanding.

(3) Interpretation of Noise Impact Descriptors

As mentioned above the noise descriptors discussed here have land use planning guidelines associated with each, with the exception of ASDS which is still undergoing refinement by the FAA. Exhibit B-2 presents the various guidelines.

A very important concept to keep in mind in interpreting the results presented in this appendix is that noise descriptors in this analysis are usually used to determine relative differences in various airport development alternatives. This concept has been carried through in airport planning for the San Francisco Bay Region. The NEF methodology was used in evaluating the various airport systems developed in the Regional Airport System Plan. The results should not be interpreted as a proxy for actual noise measurement and monitoring. Likewise, it should be understood that the noise analyses of this study are essentially a comparative evaluation and the results of the analyses, therefore, characterize

EXHIBIT B-2

San Francisco International Airport

PLANNING GUIDELINES

CNR

Composite Noise Rating		Description of Expected Response
Takeoffs & Landings	Runups	
Less than 100	Less than 80	Essentially no complaints, noise may interfere occasionally with certain activities of residents
100 to 115	80 to 95	Individuals may complain, perhaps vigorously, concerted group action possible
Greater than 115	Greater than 95	Individual reactions would likely include repeated vigorous complaints. Concerted group action might be expected.

NEF

Generalized Land Use	Net Range	General Land Use Recommendation
1. Residential and Educational	less than 30	Satisfactory, with little noise impact and requiring no special noise insulation requirements for new construction.
	30 to 35	New construction or development should be undertaken only after an analysis of noise reduction requirements is made and needed noise insulation features included in the design.
	greater than 35	New construction or development should not be undertaken.
2. Commercial	less than 35	Satisfactory, with little noise impact and requiring no special noise insulation requirements for new construction.
	35 to 45	New construction or development should be undertaken only after an analysis of noise reduction requirements is made and needed noise insulation features included in the design.
3. Industrial	less than 40	Satisfactory, with little noise impact and requiring no special noise insulation requirements for new construction.
	40 to 50	New construction or development should be undertaken only after an analysis of noise reduction requirements is made and needed noise insulation features included in the design.

Generalized Land Use	NEF Net Range	General Land Use Recommendation
	greater than 50	New construction or development should not be undertaken unless related to airport activities or services. Conventional construction will generally be inadequate and special noise insulation features should be included in construction.
4. Open	less than 40	Satisfactory, with little noise impact and requiring no special noise insulation requirements for new construction.
	greater than 40	Land uses involving concentrations of people (spectator sports and some recreational facilities) or of animals (livestock farming and animal breeding) should generally be avoided.

CNEL

1. Critical CNEL value in decibels

Date	CNEL
. Effective date of regulations to 12-31-75	80
. 1-1-76 to 12-31-80	75
. 1-1-81 to 12-31-85	70
. 1-1-86 and thereafter	65

2. Compatible land uses within critical CNEL

- Agricultural
- Airport property
- Industrial property
- Commercial property
- Property subject to avigation easement for noise
- Zoned open space
- High rise apartments that have been acoustically treated
- For existing airports and existing homes, residential areas in which existing homes have been acoustically treated.

the relative noise impacts for the various development alternatives for San Francisco International Airport. The results of this study are also not a proxy for actual noise measurement and monitoring.

3. DESCRIPTION OF METHODOLOGY

Two noise descriptors were used to analyze the noise impact for SFIA, the CNEL as required by California law and the ASDS as required by the FAA. These two techniques are quite different in concept but share a common feature in that both techniques describe the noise environment in terms of a number of single event noise exposures.

(1) Community Noise Equivalent Level (CNEL)

The Community Noise Equivalent Level (CNEL) is derived from the California law prescribing noise monitoring techniques (8). The CNEL and earlier NEF methodology are very similar in concept and application; the main differences being:

- CNEL uses A-weighted noise levels while NEF uses effective perceived noise levels
- CNEL weights aircraft operations during the evening hours (1900-2200 hours) more heavily than NEF. However, NEF weights nighttime operations (2200-0700 hours) more heavily than CNEL.

CNEL describes noise at a particular point on the ground as a function of the Single Event Noise Exposure Level (SENEL) and

the number of aircraft operations. For various aircraft types, there exist SENEL versus distance tables that express the noise characteristics for a single landing or takeoff as a function of distance.

The basic equation used in CNEL is

$$CNEL = SENEL + 10 \log_{10} (N_D + 3N_E + 10N_N) - 49.4$$

where

N_D = number of daytime (0700-1900) operations
N_E = number of evening (1900-2200) operations
N_N = number of nighttime (2200-0700) operations

Thus for a given aircraft type, given flight track and given distance, the CNEL value at a point on the ground is the SENEL value read from the SENEL versus distance tables plus an adjustment for the weighted number of operations.

Basic input requirements for CNEL include

- Number of operations by aircraft type
- Number of operations by time of day
- Number of operations on each flight track

Each of these is discussed in more detail in the next section.

(2) Computer Program Development for CNEL

As mentioned, the NEF and CNEL methodologies are quite similar in concept and application. This fact was exploited in developing the computer programs for CNEL. A NEF computer program was originally

developed for the FAA by Bolt, Beranek, and Newman and a source listing appeared in FAA report 70-6 (13). This program was modified for system compatibility and easier input techniques. An alternative geometric technique was also incorporated to compute perpendicular distances from a point on the flight path to a constant NEF value contour line.

The CNEL program was adapted from the NEF program to include:

- Use of three daily periods (day/evening/night) with different weighting schemes
- Use of SENEL profile tables, in dBA.
- Program modification to account for various threshold values as specified in the California noise law (8).

The program logic for NEF and CNEL are essentially the same.

Exhibit B-3 depicts a macro flow chart of the program logic. Output from computer programs consists of CNEL contours for each flight track in tabular form (CNEL versus distance from the flight track centerline.) CNEL contours can then be plotted from the tables.

(3) Aircraft Sound Description System (ASDS)

The Aircraft Sound Description System is described in a four-volume report (14). The basic premise of the ASDS concept is

EXHIBIT B-3

San Francisco International Airport

MACRO-FLOW CHART
CNEL COMPUTER PROGRAM

1
SELECT FLIGHT TRACK N - LABEL F_n
2
SELECT POINT I ON FLIGHT TRACK N - LABEL POINT X_{in}
SELECT SIDELINE POINT FOR X_{in} - LABEL POINT S_{xin}
SELECT AIRCRAFT TYPE K - LABEL A_k
COMPUTE WEIGHTED SUM OF OPERATIONS FOR FLIGHT TRACK I, AND AIRCRAFT TYPE K - LABEL WS_{ik}
10
10
COMPUTE CNEL VALUE AT SIDELINE POINT S_{xin}, FOR AIRCRAFT TYPE A_k - LABEL C_{kxin}
HAVE ALL AIRCRAFT TYPES BEEN CONSIDERED?
NO
YES
IS THE CALCULATED CNEL VALUE, C_{kxin}, THE DESIRED VALUE?
NO
YES
SELECT NEW SIDELINE POINT - S_{xin}
20
20
HAVE ALL POINTS BEEN CALCULATED ON FLIGHT TRACK N?
NO
YES
SELECT NEW POINT ON FLIGHT TRACK F_n - LABEL X_{in}
2
STORE AND SELECT NEW FLIGHT TRACK F_n
1

straightforward; exposure to aircraft noise is described in terms of the total amount of time that sound levels exceed a preselected threshold value. Noise exposure is defined by the statement "X minutes of total exposure to sound levels in excess of 85 dBA".

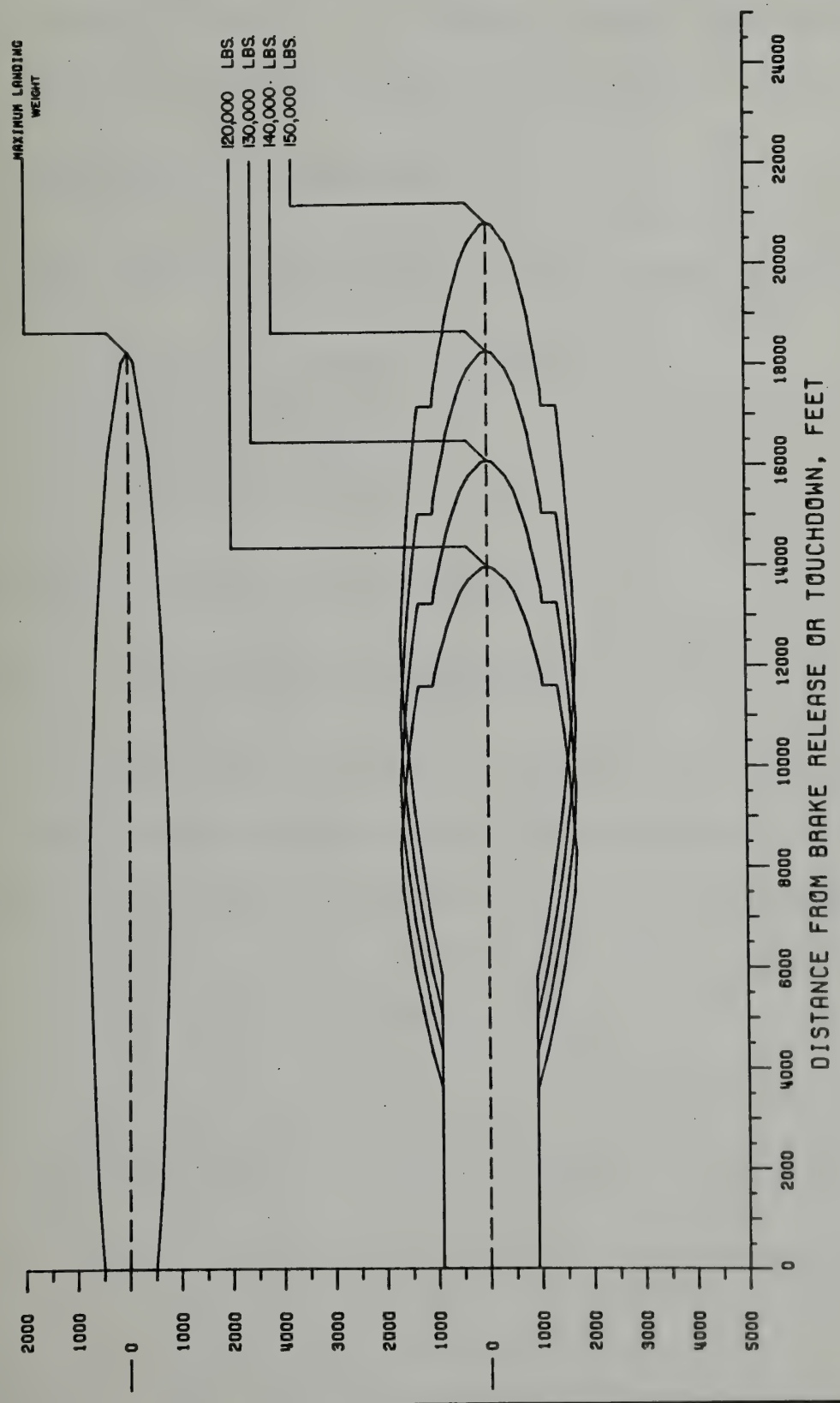
An ASDS single event sound contour describes the locus of points on the ground that are exposed to sound levels equal to 85 dBA for a particular length of time. For takeoffs, the time duration of this sound level is a constant 15 seconds and for landings the time duration is ten seconds. Single event sound contours have been developed for 51 aircraft types at various operating weights for a total of 240 single event sound contours. Exhibit B-4 depicts the single event sound contours for a B-727-100 for landings and takeoffs. Thus for a landing by a B-727-100, the single event sound contour depicts the locus of points on the ground that are exposed for ten seconds to a sound level equal to 85 dBA. The area within the contour is exposed to a sound level of 85 dBA for longer periods of time.

Input requirements for ASDS are similar to the input requirements for CNEL, with one major difference. Since ASDS does not weight the single event noise levels by time of day, a breakdown of day/evening/night operations is not required. However, the ASDS contours could be described separately in terms of those operations that occur only in the daytime, evening, and nighttime respectively.

EXHIBIT B-4

San Francisco International Airport

ASDS SINGLE EVENT
SOUND CONTOUR, B-727-100



(4) Computer Program Development for ASDS

The FAA publication Aircraft Sound Description System -- Application Procedures, FAA-EQ-74-2, (14) contains a listing of the computer program developed for the government to calculate ASDS contours. This program was used to calculate and plot the ASDS contours of this report.

4. INPUT DATA REQUIREMENTS

The input data requirements for the CNEL and ASDS methodologies are:

- Runway end utilization distributions
- Number of aircraft operations
- Fleet mix distribution
- Stage length distribtuion
- Flight track distribution

Each of these is discussed in more detail below.

(1) Runway Utilization Distributions

Runway utilization distributions refer to the percentage of time that aircraft operations occur from a particular runway. At SFIA the majority of takeoffs occur from runways 1L and 1R and the majority of landings occur on runways 28L and 28R. This operating configuration allows departures and arrivals over water.

Seasonal wind shifts in the San Francisco Bay region cause a significant difference in runway utilizations during the months

of May and June. During these months, the percentage of takeoffs from runways 28L and 28R almost doubles, which in turn causes more noise exposure over populated areas. Noise contours were developed for both the annual and seasonal runway distributions.

Runway utilizations were obtained from analysis of FAA Control Tower records for 1974. These records show the number of operations by runway for every hour in the year. These data were coded for computer use and a program was written determining the percentage of time that the runways were used by time of day. Thus, both the runway distributions and day/evening/night distributions were obtained concurrently. The time intervals used were those specified by the California noise laws and are:

- Daytime operations 0700-1900 hours
- Evening operations 1900-2200 hours
- Nighttime operations 2200-0700 hours.

Exhibit B-5 depicts the actual distributions for 1974 for both the annual and seasonal cases. The numbers are in percentages and were rounded to the nearest whole percent. The distributions shown in Exhibit B-5 were used throughout the analysis.

(2) Number of Aircraft Operations

Appendix A detailed the annual level of operations expected at SFIA. Briefly these total annual operations are:

EXHIBIT B-5

San Francisco International Airport

RUNWAY DISTRIBUTION BY
TIME OF DAY
(ANNUAL)

LANDINGS

	Runway				
	28	10	1	19	Total
Day	55%	1%	0%	4%	60%
Evening	21	0	0	2	23
Night	15	0	0	1	17
Total	92%	1%	0%	7%	100%

TAKEOFFS

	Runway				
	28	10	1	19	Total
Day	15%	5%	46%	1%	68%
Evening	8	1	8	0	16
Night	3	1	12	0	16
Total	26%	7%	66%	1%	100%

EXHIBIT B-5

San Francisco International Airport

RUNWAY DISTRIBUTIONS BY
TIME OF DAY
(SEASONAL)

LANDINGS

	Runway				
	28	10	1	19	Total
Day	60%	0%	0%	1%	61%
Evening	22	0	0	0	22
Night	17	0	0	0	17
Total	99%	0%	0%	1%	100%

TAKEOFFS

	Runway				
	28	10	1	19	Total
Day	30%	0%	37%	0%	67%
Evening	13	0	4	0	17
Night	6	0	10	0	16
Total	49%	0%	51%	0%	100%

- 334,683 - 1974
- 367,640 - 1982
- 361,340 - 1990

However, operations by helicopters and single and twin piston engine general aviation aircraft were not included in this analysis for the following reasons:

- Their operations constitute a small percentage (less than 20 percent) of the total activity at SFIA.
- Compared to air carrier aircraft, their noise impact is small.
- Therefore, their contribution to total noise exposure can be considered negligible.

This logic is supported by findings in previous studies, where it was found that noise exposure contours generated by these types of aircraft generally fall wholly within air carrier noise exposure contours. Therefore, the annual operations levels used in the noise analysis were:

- 270,948 for 1974
- 303,346 for 1982
- 297,046 for 1990

Operations for the average annual day and the average seasonal day were used in the analysis. Average annual day operations were obtained by dividing total annual operations used in the noise analysis by 365 days in the year. To obtain the average seasonal day operations, the percentages of total annual operations occurring during May and June of 1974 were obtained from FAA Control Tower records. These percentages were:

.	May	8.5%
.	June	8.6
.	Total	17.1

Total operations were multiplied by 17.1 percent to obtain operations in May and June and then divided by 61 days to obtain the average seasonal day operations. Results of these calculations are summarized in Exhibit B-6.

(3) Fleet Mix Distribution

The fleet mix distribution was discussed in Appendix A, and is presented here for easy reference. The fleet mix distribution was expressed in terms of classes of aircraft. The CNEL methodology utilizes these classes of aircraft to describe the SENEL curves. The ASDS methodology utilizes particular aircraft types rather than classes of aircraft types. Therefore a typical aircraft type was chosen from each class for use in ASDS.

The most widely used aircraft type in each class was chosen as the typical aircraft type for ASDS. The CAB publication Airport Activity Statistics, 1973 (the most current calendar year available) was used to select the most widely used aircraft type. Exhibit B-7 presents the fleet mix distributions used in the noise analysis.

(4) Trip Length Distribution

Depending upon the destination of a departing aircraft, the take-off weight will vary. Generally, but not in all cases, the longer the

EXHIBIT B-6

San Francisco International Airport

DAILY OPERATIONS

	1974	1982	1990
Average Annual Day			
- Landings	371	415	407
- Takeoffs	371	415	407
- Operations	742	830	814
Average Seasonal Day			
- Landings	386	432	423
- Takeoffs	386	432	423
- Operations	772	864	846

EXHIBIT B-7

San Francisco International Airport

AIRCRAFT TYPES USED FOR
ASDS ANALYSIS

CNEL Class	ASDS Typical Aircraft	Percent Distribution		
		1974	1982	1990
1	DC-8-30	3.99%	2.30%	1.45%
2	B-707-123B	24.60	14.18	8.96
3 & 4	B-727-100	30.73	16.84	15.06
5	B-737	23.77	27.65	24.99
6	B-747-100	5.29	8.37	11.33
7	L-1011	5.17	26.72	33.44
8	B-707-123B 1/	0.00	0.00	0.75
9	Gulfstream II	0.92	0.82	0.84
10	CV-580	2.15	1.64	1.67
11	CV-580	3.38	1.48	1.51
		100.00%	100.00%	100.00%

1/ There is no ASDS contour for the SST. The B-707-123B was selected because it has a very large contour.

trip length, the higher the takeoff weight. With a higher takeoff weight, flight profile characteristics are different as are the noise levels on the ground. Both the CNEL and ASDS methodologies take this into account. Therefore it was necessary to estimate stage length distributions for each aircraft type. This was accomplished by analysis of the published schedules in the 1974 Official Airline Guide. Only stage lengths for aircraft classes 1 through 8 had to be identified since neither methodology accounts for stage lengths in classes 9 through 11.

Exhibit B-8 summarizes the stage length distributions used in this analysis by time of day. Since San Francisco has probably reached its market maturity it is reasonable to expect these distributions to remain relatively constant. Therefore, the distributions shown in Exhibit B-8 were used throughout the analysis.

ASDS does not utilize stage lengths per se, but rather takeoff weights. Since takeoff weight can generally be determined from the stage length, appropriate takeoff weights were assigned to the aircraft types for ASDS. This is shown in Exhibit B-9.

(5) Flight Track Distributions

The flight track of an aircraft refers to the locus of points on the ground that lie directly beneath the aircraft when landing or taking

EXHIBIT B-8

San Francisco International Airport

STAGE LENGTH DISTRIBUTION

AIRCRAFT TYPE		STAGE LENGTH (Nautical Miles)						
CNEL Class	ASDS	0-500		500-1000	1000-1500	1500-2500	2500 +	Total
1	DC-8-30	Day	25.2%	14.5%	16.0%	37.4%	6.9%	100 %
		Evening	52.4	47.6	0.0	0.0	0.0	100
		Night	82.6	0.0	4.3	8.7	4.3	100
		Total	36.0	16.6	12.6	29.1	5.7	100
2	B-707-123B	Day	16.4	14.0	5.1	54.8	9.7	100
		Evening	74.5	20.9	0.0	2.3	2.3	100
		Night	18.9	3.8	17.9	50.8	9.4	100
		Total	20.8	12.7	6.9	50.5	9.1	100
3 & 4	B-727-100	Day	58.7	29.4	4.9	6.9	0.1	100
		Evening	85.6	14.4	0.0	0.0	0.0	100
		Night	45.7	27.7	9.6	17.0	0.0	100
		Total	60.9	27.6	4.6	6.8	0.1	100
5	B-737	Day	82.0	18.0	0.0	0.0	0.0	100
		Evening	86.8	13.2	0.0	0.0	0.0	100
		Night	100.0	0.0	0.0	0.0	0.0	100
		Total	83.9	10.1	0.0	0.0	0.0	100
6	B-747-100	Day	11.2	0.0	0.0	57.9	30.9	100
		Evening	0.0	0.0	0.0	100.0	0.0	100
		Night	0.0	0.0	0.0	100.0	0.0	100
		Total	8.8	0.0	0.0	66.9	24.3	100
7	L-1011	Day	25.0	1.2	16.3	37.5	20.0	100
		Evening	0.0	0.0	0.0	0.0	0.0	100
		Night	0.0	0.0	0.0	100.0	0.0	100
		Total	24.4	1.2	15.9	39.0	19.5	100
8	SST 1/	Day	0.0	0.0	0.0	0.0	0.0	0.0
		Evening	0.0	0.0	0.0	0.0	0.0	0.0
		Night	0.0	0.0	0.0	0.0	0.0	0.0
		Total	0.0	0.0	0.0	0.0	0.0	0.0

1/ Stage length distribution for 1990 is 100% of flight greater than 2500 miles.

EXHIBIT B-9

San Francisco International Airport

TAKEOFF WEIGHTS
ASDS

CNEL Class	Typical ASDS Aircraft	Stage Length 0-500 Takeoff Weight	500-1000 Takeoff Weight	1000-1500 Takeoff Weight	1500-2500 Takeoff Weight	2500 + Takeoff Weight
1	DC-8-30	200,000 lbs.	220,000 lbs.	300,000 lbs.	300,000 lbs.	300,000 lbs.
2	B-707-120B	180,000	180,000	200,000	200,000	240,000
3 & 4	B-727-100	120,000	130,000	140,000	150,000	150,000
5	B-737	90,000	90,000	100,000	100,000	100,000
6	B-747-100	550,000	550,000	550,000	550,000	575,000
7	L-1011	300,000	320,000	340,000	360,000	400,000
8	B-707-120B	180,000	180,000	200,000	200,000	240,000

off. SFIA is characterized by a complex set of flight tracks for both landings and takeoffs. The flight track geometry was derived from Jeppeson Airway Manual (15) which publishes standard instrument departure routes (SID) and standard terminal arrival routes (STAR) for airports in the United States.

For SFIA, all arrival flight tracks are straight in for a distance of five to ten miles from the runway end with the exception of arrivals on 1R and 1L. Since the SENEL flight profiles used in CNEL and the single event noise contours used in ASDS do not indicate noise levels above the critical value at these distances, all arrival flight tracks were assumed to be straight in. Arrivals on 1R and 1L occurred with small frequency, (zero percent when rounded to the nearest whole percent) and were ignored.

Departure flight tracks, on the other hand, exhibit quite complex geometry close to the airport. Exhibit B-10 depicts the departure flight tracks used in the analysis along with the arrival flight tracks for runways 28, 10 and 19. The frequency of use of these departure flight tracks was obtained from the FAA Control Tower flight strips. These flight strips show, among other things, departure time, aircraft type, and the SID that an aircraft is to fly. A sample of six days was taken and the information coded for computer analysis. The six days chosen were:

EXHIBIT B-10

San Francisco International Airport

FLIGHT TRACK GEOMETRY

- January 7, 1974
- January 8, 1974
- February 5, 1974
- May 12, 1974
- July 27, 1974
- October 27, 1974

These days were chosen on the basis of the percentage of time that the various runway configurations were in use. If a particular day had a high percentage usage of one runway configuration, that day was chosen. This ensured an accurate estimate of the flight track utilization percentages for each particular runway. For example, a day on which 100 percent of the departures occurred from runways 28L and 28R, should yield a better estimate of the flight track percentage utilizations for that runway than a day on which more than one runway was used for departures. A total of 1,883 aircraft departures were analyzed to obtain the distribution of flight track usage for each runway. Exhibit B-11 summarized the results.

As can be seen from Exhibit B-10, many flight tracks coincide, overlap and intersect. It was necessary to identify segments of flight tracks in order to estimate the correct number of departures for each segment. Exhibit B-12 depicts the segments that were identified and Exhibit B-13 summarizes the percentage distribution on each of the segments. The lettering system for the flight track segments is arbitrary. The flight track segment distributions were used throughout the analysis.

EXHIBIT B-11

San Francisco International Airport

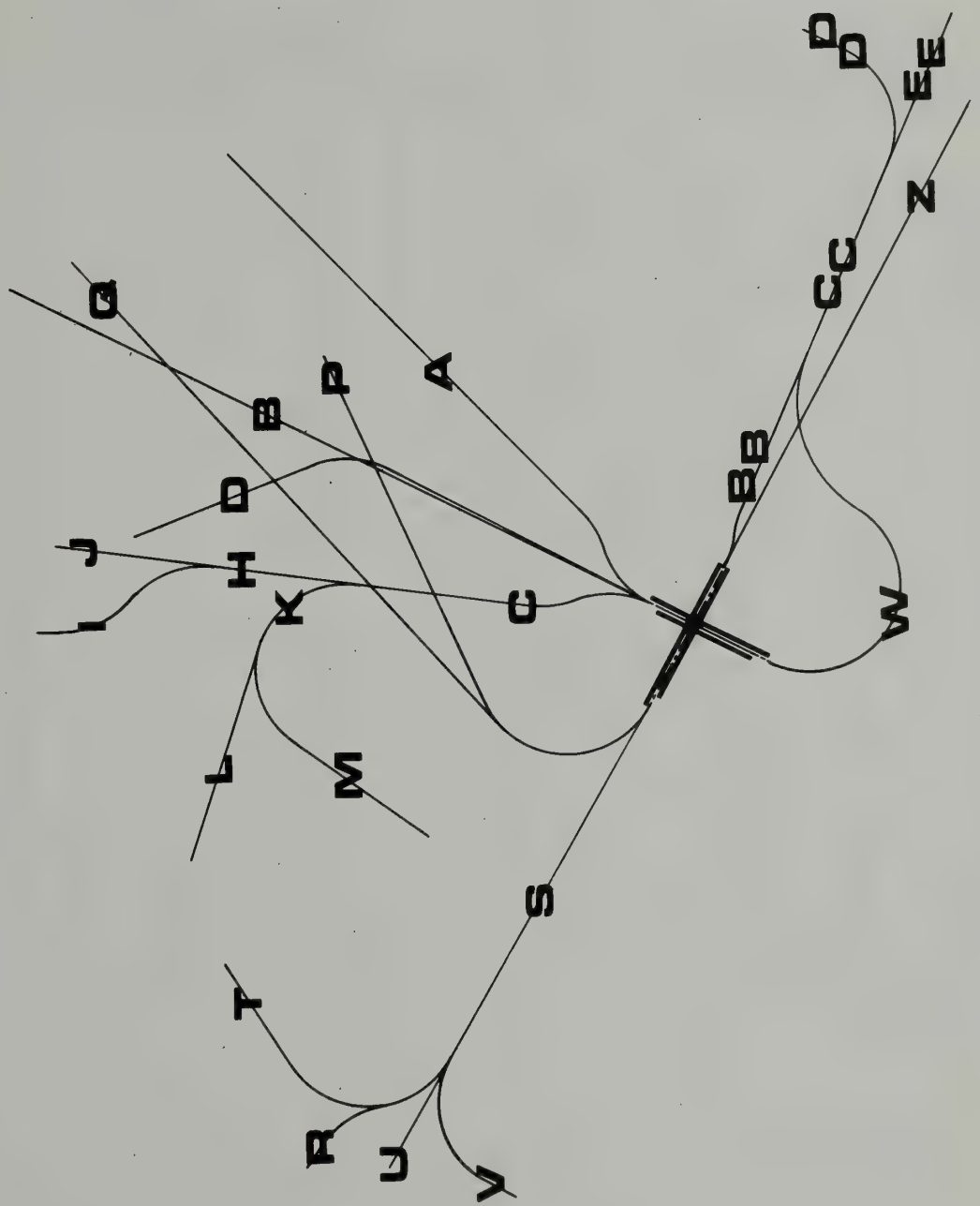
DEPARTURE FLIGHT TRACK
DISTRIBUTIONS

Flight Track		Runway 28	Runway 10	Runway 1	Runway 19
Quiet	CU	4.38%	0.00	15.33	0.00
Drake	DR	4.63	11.69	4.73	25.64
Gap	GA	5.32	0.00	0.00	0.00
Linden	LN	4.09	26.25	25.58	10.89
Point Ano	PA	2.87	0.25	2.27	0.00
Portola	PT	33.42	36.89	35.28	41.69
Red Bluff	RB	2.04	11.95	0.00	12.82
Richmond	RM	0.14	0.00	0.94	0.00
Sacramento	SA	4.50	12.20	14.77	7.04
Stinson	SB	0.96	0.77	1.13	1.92
Shoreline	SL	37.65	0.00	0.00	0.00
Total		100.00	100.00	100.00	100.00

EXHIBIT B-12

San Francisco International Airport

FLIGHT TRACK SEGMENTS



EXHBIT B-13

San Francisco International Airport

FLIGHT TRACK SEGMENT DISTRIBUTIONS
(ANNUAL)

Flight Track Segment	Percent Landings				Percent Takeoffs			
	Day	Evening	Night	Total	Day	Evening	Night	Total
A	0.00	0.00	0.00	0.00	18.56	3.23	4.84	26.63
B	4.00	2.00	1.00	7.00	0.00	0.00	0.00	0.00
C	0.00	0.00	0.00	0.00	20.38	3.54	5.32	29.25
D	0.00	0.00	0.00	0.00	7.05	1.22	1.84	10.12
H	0.00	0.00	0.00	0.00	2.61	0.45	0.68	3.74
I	0.00	0.00	0.00	0.00	2.18	0.38	0.57	3.12
J	0.00	0.00	0.00	0.00	0.43	0.08	0.11	0.62
K	0.00	0.00	0.00	0.00	17.78	3.09	4.64	25.51
L	0.00	0.00	0.00	0.00	0.52	0.09	0.14	0.75
M	0.00	0.00	0.00	0.00	17.26	3.00	4.50	24.76
O	0.00	0.00	0.00	0.00	6.30	3.36	1.26	10.93
P	0.00	0.00	0.00	0.00	0.66	0.35	0.13	1.14
Q	0.00	0.00	0.00	0.00	5.65	3.01	1.13	9.79
R	0.00	0.00	0.00	0.00	0.14	0.08	0.03	0.25
S	1.00	0.00	0.00	1.00	8.69	4.64	1.74	15.07
T	0.00	0.00	0.00	0.00	0.02	0.01	0.01	0.04
U	1.00	0.00	0.00	1.00	3.09	1.65	0.62	5.35
V	0.00	0.00	0.00	0.00	5.44	2.90	1.09	9.43
W	0.00	0.00	0.00	0.00	1.00	0.00	0.00	1.00
Z	55.00	21.00	15.00	92.00	0.00	0.00	0.00	0.00
BB	0.00	0.00	0.00	0.00	5.00	1.00	1.00	7.00
CC	0.00	0.00	0.00	0.00	6.00	1.00	1.00	8.00
DD	0.00	0.00	0.00	0.00	2.10	0.38	0.38	2.87
EE	0.00	0.00	0.00	0.00	3.90	0.62	0.62	5.13

EXHBIT B-13

San Francisco International Airport

FLIGHT TRACK SEGMENT DISTRIBUTIONS
(SEASONAL)

Flight Track Segment	Percent Landings				Percent Takeoffs			
	Day	Evening	Night	Total	Day	Evening	Night	Total
A	0.00	0.00	0.00	0.00	14.93	1.61	4.03	20.58
B	1.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
C	0.00	0.00	0.00	0.00	16.40	1.77	4.43	22.60
D	0.00	0.00	0.00	0.00	5.67	0.61	1.53	7.02
H	0.00	0.00	0.00	0.00	2.10	0.23	0.57	2.89
I	0.00	0.00	0.00	0.00	1.75	0.19	0.47	2.41
J	0.00	0.00	0.00	0.00	0.35	0.04	0.09	0.48
K	0.00	0.00	0.00	0.00	14.30	1.55	3.87	19.71
L	0.00	0.00	0.00	0.00	0.42	0.05	0.11	0.58
M	0.00	0.00	0.00	0.00	13.88	1.50	3.75	19.13
O	0.00	0.00	0.00	0.00	12.61	5.46	2.52	20.59
P	0.00	0.00	0.00	0.00	1.31	0.57	0.26	2.14
Q	0.00	0.00	0.00	0.00	11.30	4.89	2.26	18.45
R	0.00	0.00	0.00	0.00	0.29	0.12	0.06	0.47
S	0.00	0.00	0.00	0.00	17.39	7.54	3.48	28.40
T	0.00	0.00	0.00	0.00	0.04	0.02	0.01	0.07
U	0.00	0.00	0.00	0.00	6.17	2.67	1.23	10.08
V	0.00	0.00	0.00	0.00	10.89	4.72	2.18	17.78
W	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Z	60.00	22.00	17.00	49.00	0.00	0.00	0.00	0.00
BB	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

As an example of how these distributions were obtained, note that flight segment A is composed of departures from runways 1L and 1R on the following flight tracks:

- Linden
- Sacramento

From Exhibit B-11, the percentage use of these two flight tracks was 25.58 and 14.77 percent for Linden and Sacramento, respectively, for a total use of 40.35 percent. For the annual case, runways 1L and 1R are used the following percentage of time:

. Day	=	46%
. Evening	=	8
. Night	=	12
. Total	=	66%

Thus, the number of departures for the annual case, expressed as a percent, for flight segment A is:

. Day	=	18.56% (.4035 x .46 x 100)
. Evening	=	3.23
. Night	=	4.84
. Total	=	26.63

The end result of all input data was a description, for each flight track segment, of the number of operations by aircraft type, time of day and stage length (or takeoff weight). This was accomplished by coding all the input distributions for computer use and calculating the necessary

data. An example of the final input listing, for flight track segment A, 1974 annual conditions, is shown in Exhibit B-14. To present a listing of the entire set of input data used in the analysis would be too cumbersome, since it comprises a total of 168 pages and would not improve the presentation of the analysis.

(6) Assumptions Used in the Noise Analysis

Various assumptions were made for simplification and to make both methodologies consistent. All assumptions made are described below.

For plotting purposes, the parallel/intersecting runways at SFIA, were consolidated to a single set of intersecting runways. A single 10-28 runway, 12,000 feet in length and a 1-19 runway 9,500 feet in length were used with its location being halfway between the runway centerlines. Since the runway centerlines are seperated by 750 feet, the effect is to understate the sideline noise impact by approximately 375 feet. Owing to the fact that actual aircraft flight tracks often deviate from theoretical flight tracks by more than 400 feet, a plotting error of less than 400 feet was not considered significant.

Approach and takeoff profiles used were the standard profiles that were employed in developing the SENEL versus distance curves for CNEL and the single event noise contours for ASDS. These standard profiles were not changed throughout the analysis.

EXHIBIT B-14

San Francisco International Airport

EXAMPLE OF INPUT DATA

AVERAGE DAILY OPERATIONS SEASONAL
FLIGHT TRACK A

	AIRCRAFT TYPE		TOTAL LANDINGS	TOTAL TAKEOFFS	TAKEOFFS BY STAGE LENGTHS - MILES				
					0-500	501-1000	1001-1500	1501-2500	GREATER THAN 2501 MILES
1	4-ENG-TJ	DAY	0.000	2.299	.579	.333	.368	.860	.159
		EVEN	0.000	.248	.130	.118	0.000	0.000	0.000
		NIGHT	0.000	.621	.513	0.000	.027	.054	.027
		TOTAL	0.000	3.170	1.141	.526	.399	.922	.181
2	4-ENG-TF	DAY	0.000	14.177	2.325	1.985	.723	7.769	1.375
		EVEN	0.000	1.529	1.139	.320	0.000	.035	.035
		NIGHT	0.000	3.827	.723	.145	.685	1.944	.360
		TOTAL	0.000	19.542	4.065	2.482	1.348	9.869	1.778
3	3-ENG-TF	DAY	0.000	17.710	10.396	5.207	.868	1.222	.018
		EVEN	0.000	1.910	1.635	.275	0.000	0.000	0.000
		NIGHT	0.000	4.780	2.185	1.324	.459	.813	0.000
		TOTAL	0.000	24.412	14.867	6.738	1.123	1.660	.024
4	2-ENG-TF	DAY	0.000	13.699	11.233	2.466	0.000	0.000	0.000
		EVEN	0.000	1.477	1.282	.195	0.000	0.000	0.000
		NIGHT	0.000	3.698	3.698	0.000	0.000	0.000	0.000
		TOTAL	0.000	18.883	15.843	3.040	0.000	0.000	0.000
5	4-ENG-HBPW	DAY	0.000	3.049	.341	0.000	0.000	1.765	.942
		EVEN	0.000	.329	0.000	0.000	0.000	.329	0.000
		NIGHT	0.000	.823	0.000	0.000	0.000	.823	0.000
		TOTAL	0.000	4.202	.370	0.000	0.000	2.811	1.021
6	2+3ENGHBPW	DAY	0.000	2.979	.745	.036	.486	1.117	.596
		EVEN	0.000	.321	0.000	0.000	0.000	0.000	0.000
		NIGHT	0.000	.804	0.000	0.000	0.000	.804	0.000
		TOTAL	0.000	4.107	1.002	.049	.653	1.602	.801
7	SUBSONIC	DAY	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		EVEN	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		NIGHT	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		TOTAL	0.000	0.000	0.000	0.000	0.000	0.000	0.000
8	GA JET	DAY	0.000	.530					
		EVEN	0.000	.057					
		NIGHT	0.000	.143					
		TOTAL	0.000	.731					
9	4-ENG-TJ	DAY	0.000	1.239					
		EVEN	0.000	.134					
		NIGHT	0.000	.334					
		TOTAL	0.000	1.708					
10	2-ENG-TJ	DAY	0.000	1.948					
		EVEN	0.000	.210					
		NIGHT	0.000	.526					
		TOTAL	0.000	2.685					

The combined actions of the Federal Aviation Administration and the Environmental Protection Agency make implementation of some form of existing aircraft engine noise suppression retrofit program probable prior to 1980 and inevitable by 1985. Currently the FAA has published a series of Notices of Proposed Rule Makings (NPRM's) dealing with the implementation on or before 1979 of "quiet nacelle" retrofit on virtually all aircraft in the current airline inventory. The application of these proposed rules, particularly to the JT-3D and JT-8D power plants will bring them in line with current production aircraft standards under FAR-Part 36. Whether to proceed immediately the JT-8D "quiet nacelle" program or delay until the full cost/benefit picture of the NASA engine "re-fan" program is available in 1975 is being debated in Congress and elsewhere. However, the FAA plans to push ahead with rule making on the "quiet nacelle". In addition to these retrofit provisions, NPRM's have also been issued which when implemented will tighten the current FAR Part 36 production aircraft certification standards providing for staged reduction of the noise characteristics of future production aircraft.

With these developments in the offing, the CNEL and ASDS analysis has been based upon the following aircraft noise characteristics:

- 1974 - Current aircraft fleet serving SFIA.

- 1982 - Current aircraft fleet characteristics with the exception of "quiet nacelle" retrofit of JT-3D engines on B-707 and DC-8 aircraft.

- 1990 - All aircraft with the exception of the B-727 meet FAR-Part 36 requirements, the JT-8D engines on the B-727 reflecting "re-fan" retrofit.

Noise levels on the ground are dependent upon terrain conditions, temperature, humidity, and wind speeds and direction. In areas of mountainous terrain aircraft noise will be dependent upon the height of the mountains, e.g., the distance from the aircraft to the ground will be less (assuming a constant climb gradient) causing higher noise levels. For SFIA, takeoffs on 28L and 28R pass over mountainous areas unless making some type of shoreline departure. Ideally, altitude profiles for each aircraft type could be modified to account for the terrain conditions. As mentioned only standard flight and altitude profiles were used for SFIA. The reasons are:

- Terrain conditions become significant at about 25,000 feet from brake release for takeoffs on 28. At these distances, the aircraft is at sufficient altitude where various random factors such as wind speed, temperature, etc, have a strong influence on noise levels heard on the ground. Thus, any more information gained by altering the altitude profiles would most likely be lost due to random effects on propogation of the noise.

- As the distance from brake release gets longer, aircraft course deviations from the flight track segments become more pronounced. Each deviation would require a separate analysis, an almost endless task.

- Finally, the ASDS single event sound contours cannot easily be changed to account for variations in terrain. It was desirable to have both methodologies as consistent as possible.

Actual noise measurements were not taken for this study. SFIA is in the process of establishing a noise monitoring system as required by California law. Noise measurement in a study of this type would be somewhat ineffective and redundant:

- First, actual sound measurement was performed in developing the noise characteristic curves for both CNEL and ASDS methodologies
- The analysis is in terms of averages; average day, average runway end utilizations, average flight track utilizations, etc. Noise measurements at selected points on selected days would actually yield little useful information that could be generalized into a statement of average noise impact at SFIA. Rather, an extensive program like the one under implementation would be required.
- Random effects in the propagation of sound, mentioned earlier, would result in selected noise measurements being of little value relative to generalized statements of noise impact.

Thus, for the purposes of this study, actual noise measurements were not considered essential.

A number of assumptions were made that related to data availability and the value of additional information. These were:

- Aircraft classes 3 and 4 include the B-727-100 and B-727-200 respectively. These classes were consolidated since their noise characteristics are quite similar.

- For ASDS analysis, the CV-580 was substituted for the typical aircraft type for class 10 (4 engine turboprop), since no 4-engine turboprop single event sound contours are available from FAA.

- Brake release was set at 200 feet from the runway end and touchdown point at 1,000 feet from the runway end.

- For the supersonic aircraft class (Class 8), little information is available concerning noise characteristics. For this analysis, the noise characteristics of the B-707-120B were used for the supersonic aircraft type. Considering the number of daily operations and the time frame, any errors in this assumption would be negligible.

- Input data distributions were considered to be independent.

The sections that follow describe the noise impact for SFIA under the various conditions discussed.

5. IMPACT ANALYSIS

Noise impact due to aircraft operations at SFIA was evaluated for the following cases:

- 1974 (annual and seasonal)
- 1982 (annual and seasonal)
- 1990 (annual and seasonal)

The approach generally taken in evaluating noise impact is to relate noise exposure to various land uses and population. This approach provides meaningful criteria which in turn can be used to judge the relative noise impact of various

airport development alternatives. In this analysis, 2 alternative possible futures are of interest, namely, implementation of the proposed terminal complex development plan, and do nothing. As discussed,in Appendix A, aircraft traffic at SFIA can be expected to be the same in future years whether or not the proposed terminal complex expansion is implemented. Thus, it is literally true, that the proposed terminal expansion will have no impact on community exposure to aircraft noise in future years.

Recognizing, though, that while it is not relevant to a go or no go decision on the terminal complex expansion, a forecast of community exposure to aircraft noise at SFIA is nevertheless of some interest. Therefore, the remainder of this appendix presents a picture of noise exposure (with or without the proposed terminal complex expansion) for the years 1974, 1982 and 1990.

(1) Criteria for Measuring Noise Impact

The criteria for measuring noise impact consisted of four parameters:

- Acres of land (in various zoning classifications) within the various noise contours
- Number of residences within the various noise contours
- Number of people living within the various noise contours
- Number of schools within the various noise contours.

The California legislation dealing with noise impact around airports (8), was used as a guideline in assessing land use compatibility. This law prescribes land use categories that are compatible with predefined noise levels. The compatible land uses are:

- Agricultural property
- Airport property
- Industrial property
- Commercial property
- Property subject to an avigation easement for noise
- Zoned open space
- Acoustically treated high rise apartments
- Existing single family homes that are acoustically treated

Land use data were collected from the communities surrounding SFIA and, in addition, a regional land use map, derived from the Atlas of Urban and Regional Change (16), was examined. The regional land use map was more complete and homogenous than were the land use data collected from the various individual communities. Therefore, the regional map was used as the base for evaluating noise impact on land uses. The categories of land use in the regional map were condensed into seven classifications:

- Single-family residential
- Multi-family residential
- Agricultural

- Commercial
- Industrial
- Open space
- Airport

The impact of noise upon land use was calculated by overlaying the noise contours on the land use map and determining the acreage of each land use within each noise contour.

No distinction was made between residential areas in which homes were or were not acoustically treated. If any residential area fell within the critical CNEL contour, that area was considered incompatible. Exhibit B-15 depicts the land use map used in this study.

Population and residence data were obtained from the ABAG/MTC forecasts (23). This document projects population, dwelling units, employment, acres of urbanized area, residential area, and unusable area for 290 zones in the Bay area. Exhibit B-16 depicts the study zones that are impacted by aircraft noise from SFIA.

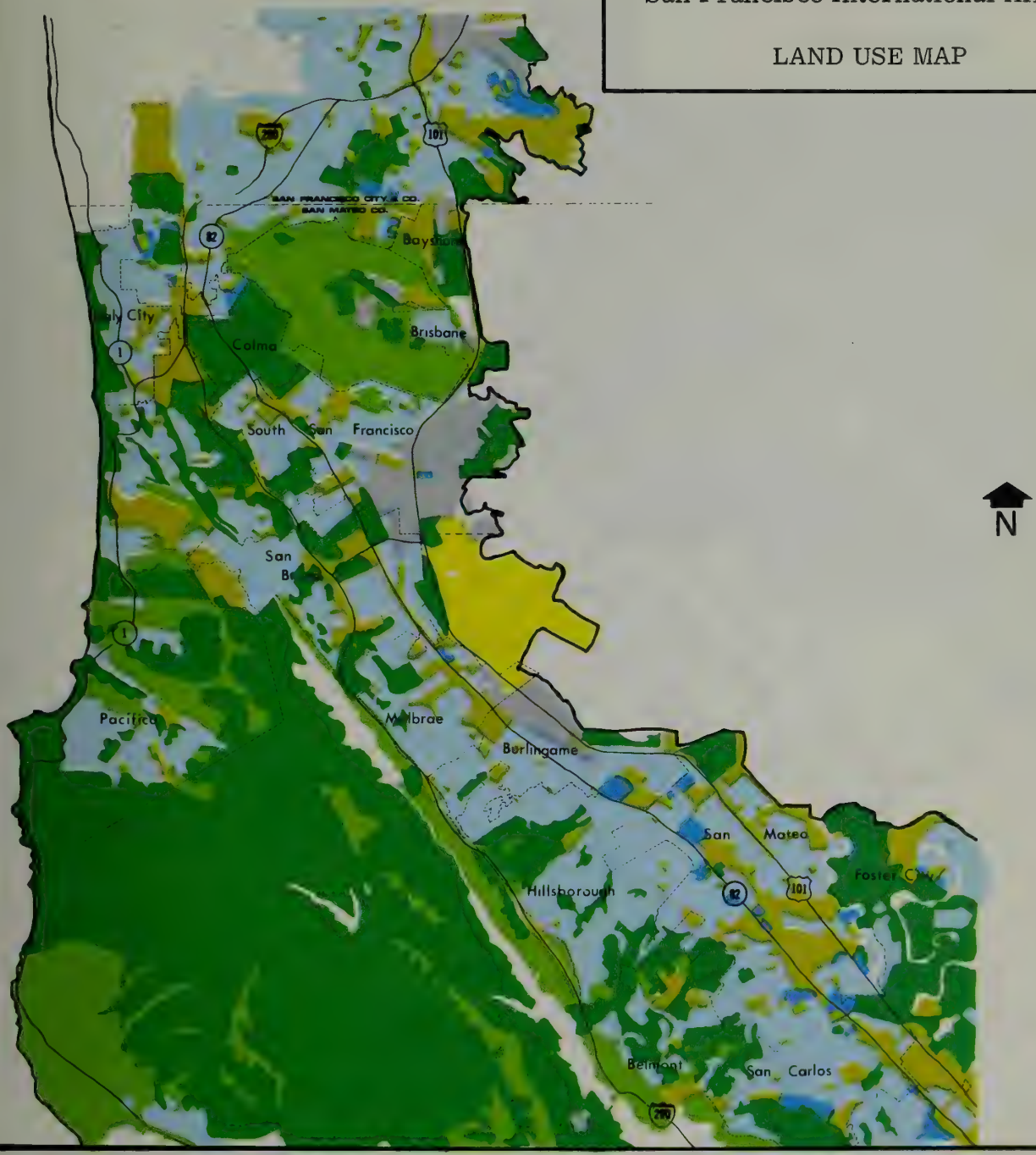
From the forecasts presented in (17), two parameters were calculated and when used in conjunction with the land use analysis above, provided estimates for population and residences within various noise contours. The two parameters were:

- dwellings per residential acre
- persons per dwelling

EXHIBIT B-15

San Francisco International Airport

LAND USE MAP



LEGEND

- San Francisco Intl. Airport
- Single Family Residential
- Multi-Family Residential
- Commercial
- Industrial
- Agriculture
- Open Space

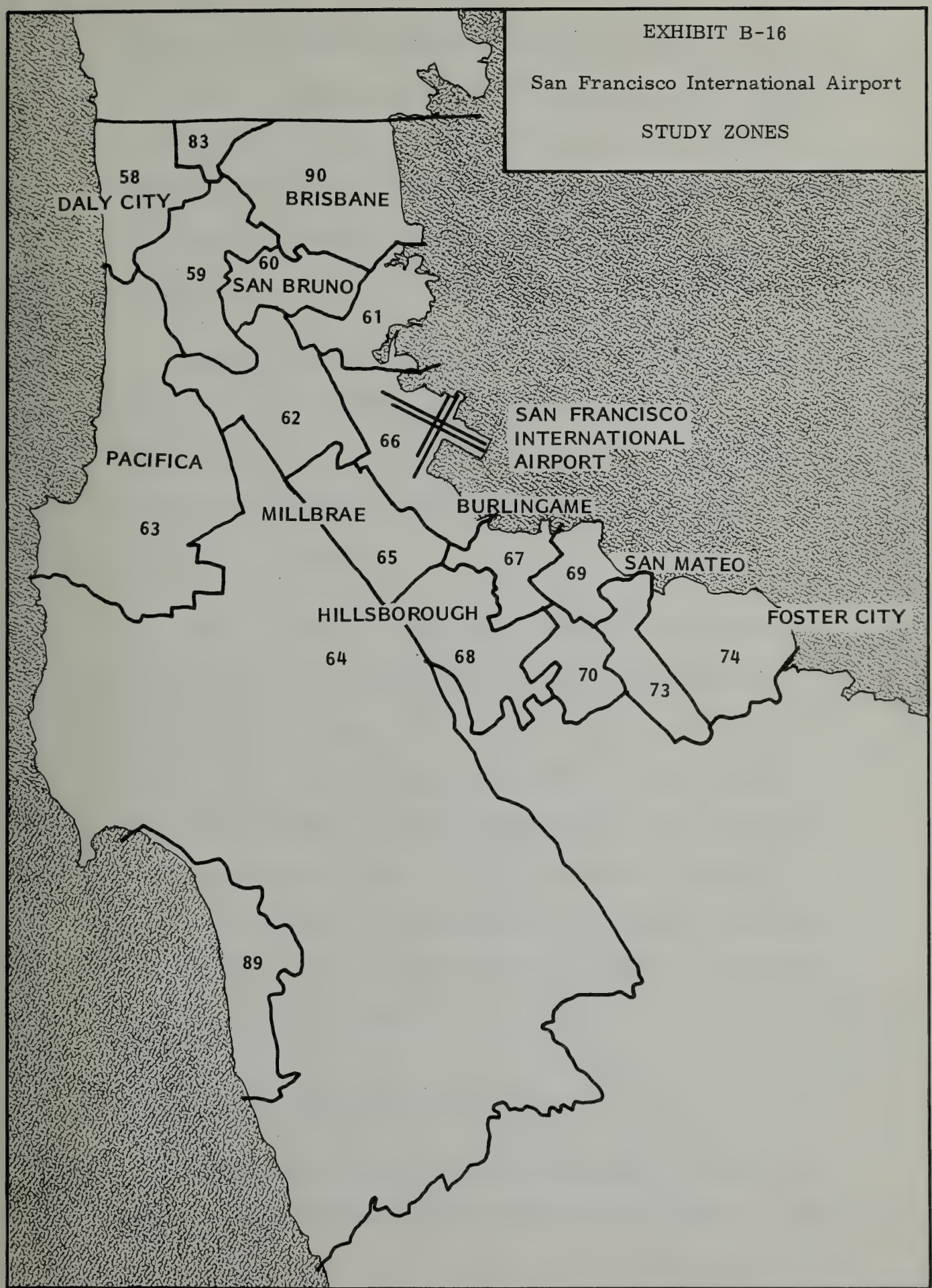


EXHIBIT B-16
San Francisco International Airport
STUDY ZONES
83
58
DALY CITY
90
BRISBANE
59
60
SAN BRUNO
61
62
66
SAN FRANCISCO
INTERNATIONAL
AIRPORT
PACIFICA
63
MILLBRAE
BURLINGAME
65
67
69
SAN MATEO
HILLSBOROUGH
FOSTER CITY
64
68
70
73
74
89

The number of residences affected for existing and future years was calculated by multiplying the residential acres in each zone and the dwellings per residential acre in each zone. Population was then obtained by multiplying dwellings and person per dwelling. Exhibit B-17 summarizes the population and residence data used in the analysis.

Another parameter used in measuring noise impact was the number of schools within the various noise contours. Schools were located on the base land use map from the directory of public schools of San Mateo County and from the Archdiocese of San Francisco's Department of Education.

As can be seen, the noise impact assessment methodology was based on the California legislation dealing with CNEL noise contours. The ASDS methodology, at the present time, has no associated land use guidelines. In order to provide a consistent set of measures for both ASDS and CNEL, the impact assessment methodology discussed above was also used for ASDS. However, for ASDS, there is no guideline that stipulates a given land use is incompatible for a given ASDS contour and as such no conclusions regarding compatible land use can be made with ASDS.

(2) Impact Assessment for 1974

Annual and seasonal CNEL noise contours for conditions existing in 1974 are shown in Exhibits B-18 and B-19 respectively. ASDS

EXHIBIT B-17

San Francisco International Airport

POPULATION AND DWELLING
UNIT PARAMETERS

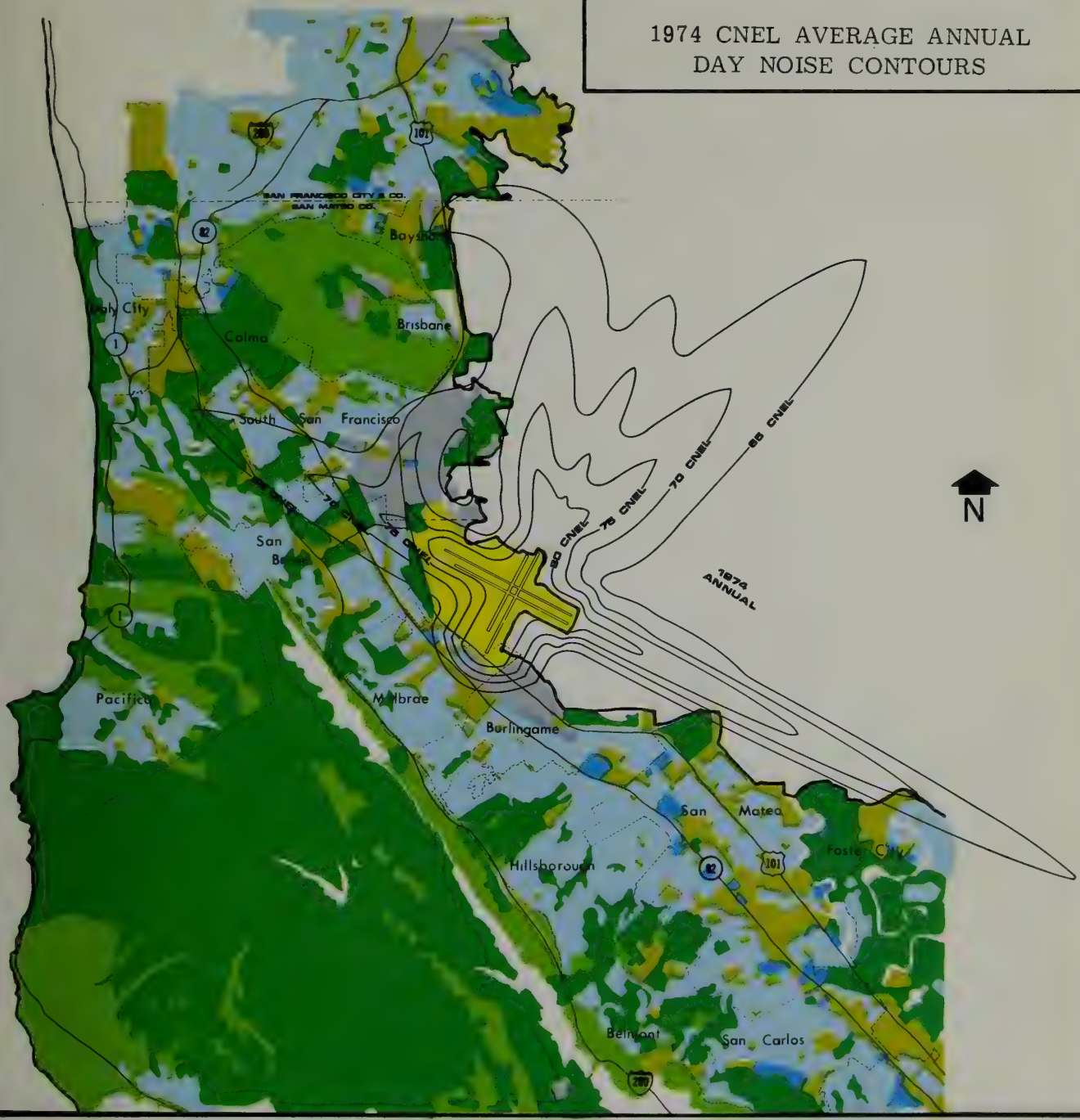
Planning Zone	Area	Population Per Dwelling Unit			Dwelling Units Per Residential Acre		
		1974	1982	1990	1974	1982	1990
58	Daly City	3.02	2.99	2.97	13.4	13.7	13.9
59	South City-Colma	3.53	3.09	2.93	9.3	11.9	12.3
60	South City-Colma	3.11	3.03	3.51	11.3	12.6	14.0
61	South City-Colma	3.52	3.51	3.51	12.6	18.5	18.7
62	San Bruno	3.16	3.00	2.94	9.0	9.9	10.7
63	Pacifica	3.66	3.56	3.50	7.2	7.6	8.0
64	S. Coastside	2.96	2.61	2.46	3.2	3.9	4.6
65	Millbrae	2.87	2.57	2.58	6.7	7.9	7.9
66	Airport	2.52	2.41	2.38	12.2	13.5	14.5
67	Burlingame	2.29	2.25	2.24	9.6	10.1	10.6
68	Hillsborough	3.26	3.08	3.01	1.4	1.5	1.7
69	San Mateo	2.34	2.29	2.25	13.7	15.4	17.6
70	San Mateo	2.42	2.30	2.24	9.2	10.8	12.6
73	San Mateo	3.16	3.14	3.13	7.9	8.2	8.5
74	Foster City	3.33	2.94	2.78	7.0	8.2	9.5
83	Daly City	3.14	3.05	3.00	17.9	19.0	20.3
89	S. Coastside	3.04	2.75	2.64	4.3	4.9	5.5
90	Brisbane	2.84	2.62	2.53	10.6	11.8	12.9

Source: Summary of Series 2 Projections, ABAG/MTC, August, 1973.

EXHIBIT B-18

San Francisco International Airport

1974 CNEL AVERAGE ANNUAL
DAY NOISE CONTOURS



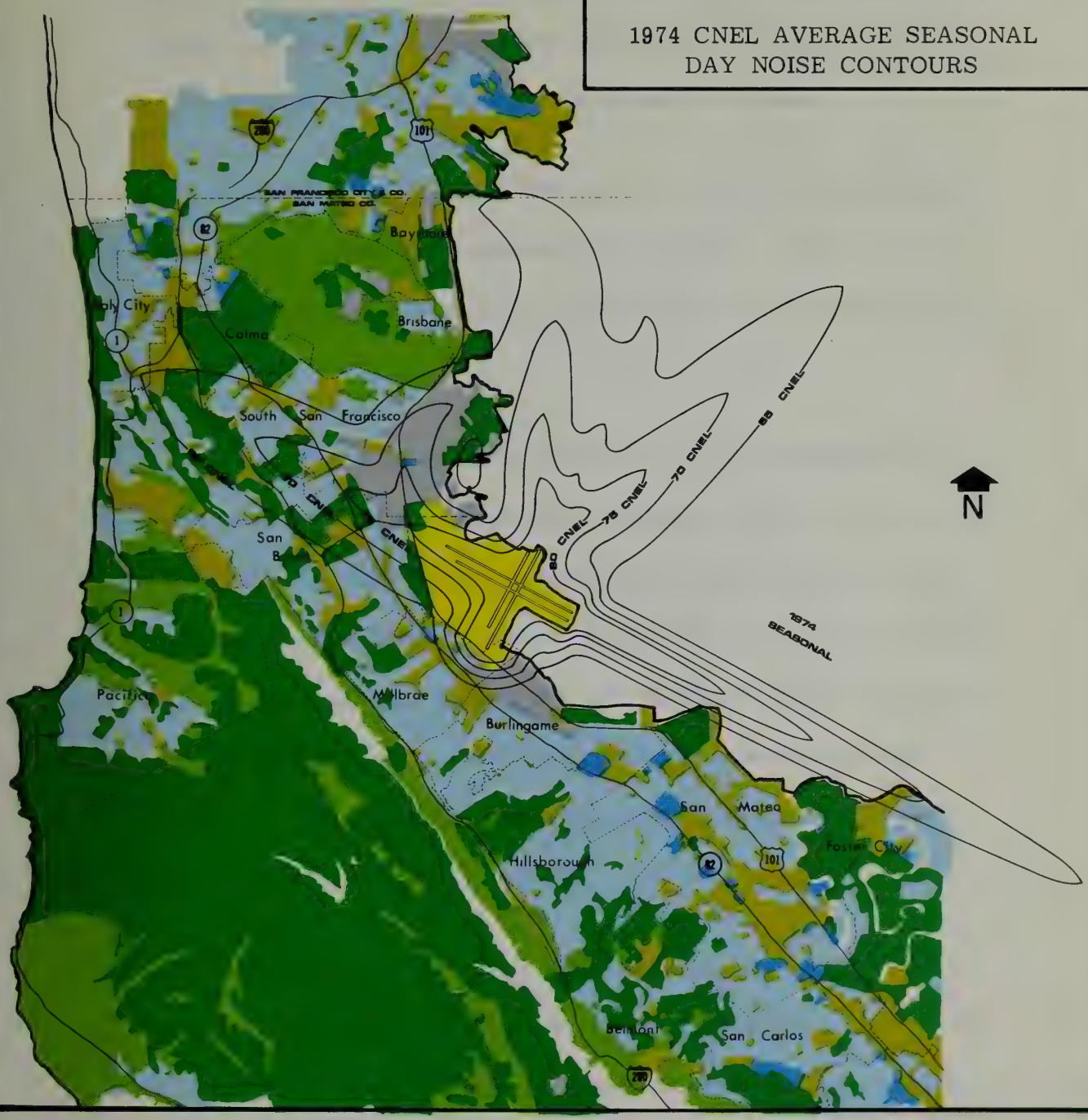
LEGEND

- San Francisco Intl. Airport
- Single Family Residential
- Multi-Family Residential
- Commercial
- Industrial
- Agriculture
- Open Space

EXHIBIT B-19

San Francisco International Airport

1974 CNEL AVERAGE SEASONAL DAY NOISE CONTOURS



LEGEND

- San Francisco Intl. Airport
- Single Family Residential
- Multi-Family Residential
- Commercial
- Industrial
- Agriculture
- Open Space

contours for the annual and seasonal cases are shown in Exhibits B-20 and B-21 respectively. Caution should be exercised in attempting to compare the CNEL contours with the ASDS contours, since the two noise descriptor systems are quite different in concept.

As can be seen from the exhibits, the major portion of the area encompassed by the noise contours is over water. Land areas impacted by the noise contours lie primarily along the 10-28 runway centerlines.

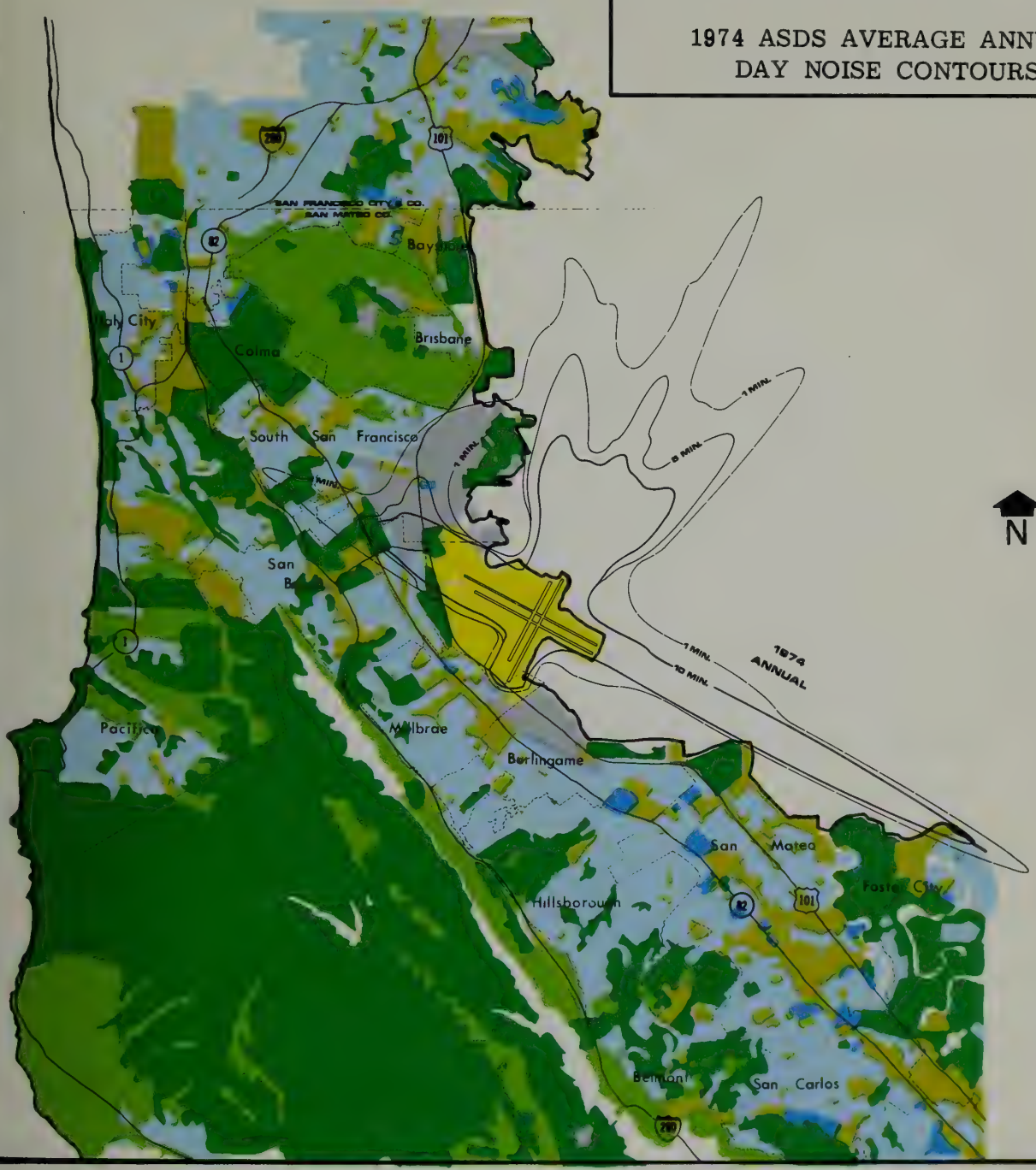
As expected the shape of the noise contours changed when going from the annual average day conditions to the seasonal average day conditions. The change in shape can be attributed to a higher proportion of takeoffs on runways 28L and 28R during the months of May and June. For CNEL contours, the change in shape is generally a widening of the contours from runways 28L and 28R while for ASDS the change in shape is characterized by a lengthening of the contours from runways 28L and 28R.

In interpreting the ASDS contours, it is important to keep in mind that the contours are the locus of points of equal time exposure to 85 dBA. The points on the one minute contour line are exposed to a noise level of 85 dBA for one minute a day. The area lying within the one-minute contour is, thus, exposed to a noise level of 85 dBA for longer than one minute a day.

EXHIBIT B-20

San Francisco International Airport

1974 ASDS AVERAGE ANNUAL
DAY NOISE CONTOURS



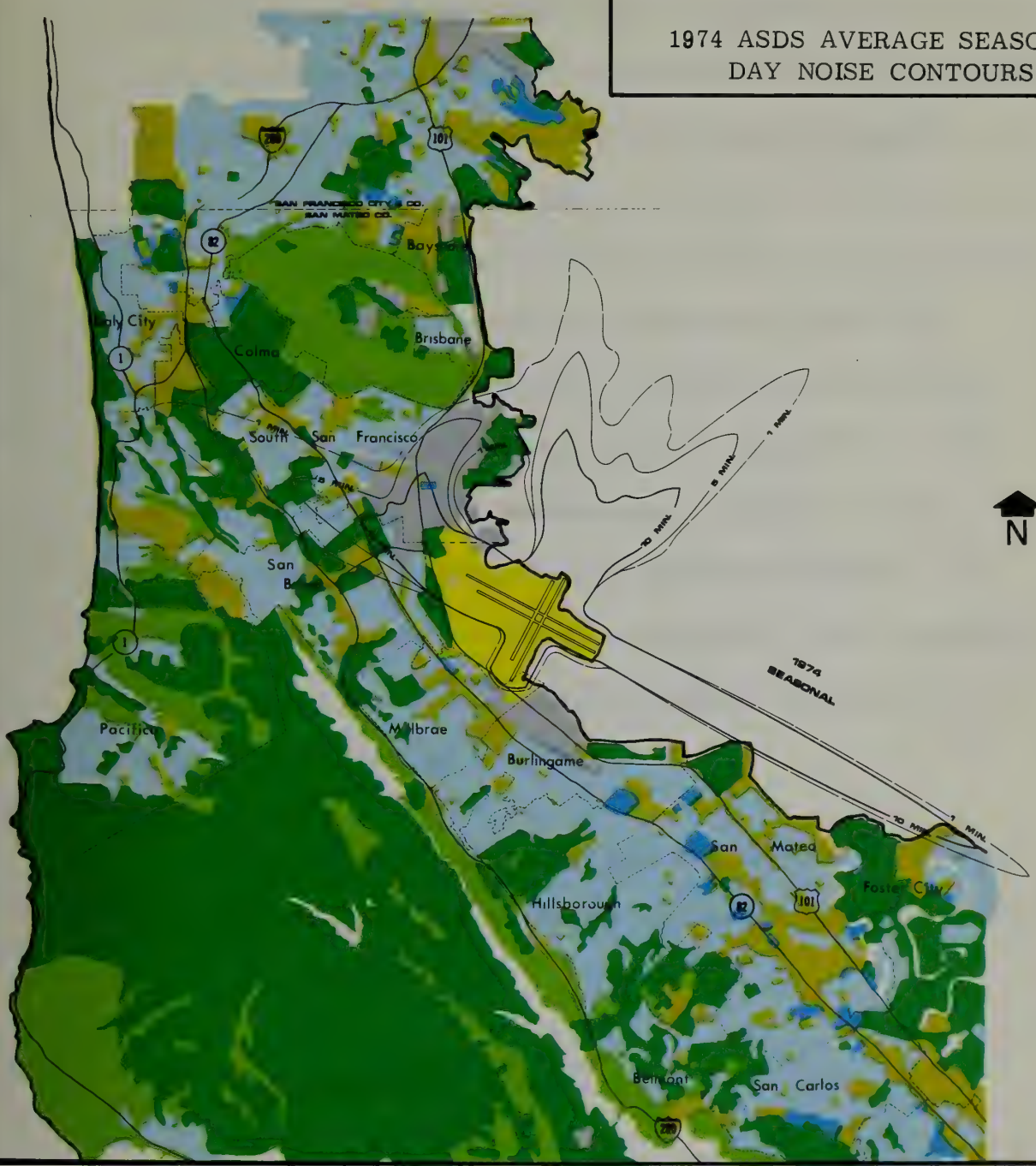
LEGEND

- San Francisco Intl. Airport
- Single Family Residential
- Multi-Family Residential
- Commercial
- Industrial
- Agriculture
- Open Space

EXHIBIT B-21

San Francisco International Airport

1974 ASDS AVERAGE SEASONAL
DAY NOISE CONTOURS



LEGEND

- San Francisco Intl. Airport
- Single Family Residential
- Multi-Family Residential
- Commercial
- Industrial
- Agriculture
- Open Space

The noise impact is summarized in tabular form in Exhibits B-22 and B-23 for the CNEL and ASDS contours respectively. For the year 1974, according to the California noise legislation, the critical contour is the 80 CNEL contour. Any schools or residences (lying within this contour) that have not been acoustically treated are incompatible land uses. As mentioned, no distinction was made in this analysis between treated and un-treated residences, and therefore all residential area within the 80 CNEL contour line for 1974 was considered incompatible. The incompatible land areas are essentially the same for both the annual and the seasonal case. Approximately three acres of single family residential area lie within the 80 CNEL contour with approximately 35 homes and 90 people. This incompatible area is located just south of runways 1L and 1R. No schools are located within the 80 CNEL contour.

Since no land use guidelines currently exist for ASDS contours, no statements can be made regarding incompatible land uses relative to the ASDS contours.

(3) Impact Assessment for 1982

Annual and seasonal CNEL contours for 1982 conditions are shown in Exhibits B-24 and B-25 respectively. ASDS contours for the annual and seasonal case are shown in Exhibits B-26 and B-27 respectively.

EXHIBIT B-22

San Francisco International Airport

NOISE IMPACT SUMMARY
CNEL 1974

LAND USE CATEGORY (ACRES)	Within 80 CNEL		Within 75 CNEL		Within 70 CNEL		Within 65 CNEL	
	Annual	Seasonal	Annual	Seasonal	Annual	Seasonal	Annual	Seasonal
Single Family Residential	3	3	55	108	258	630	1,252	2,125
Multi-Family Residential	0	0	0	0	17	17	17	17
Commercial	0	0	6	1	74	193	592	896
Industrial	16	7	90	245	535	1,044	1,680	1,848
Agriculture	0	0	0	0	0	0	0	16
Open Space	0	10	50	133	226	423	1,083	1,598
Airport	1,131	1,235	1,402	1,571	1,653	1,828	1,714	2,268
Total	1,150	1,255	1,603	2,058	2,763	4,135	6,338	8,768
POPULATION AND RESIDENCES								
People	86	86	1,694	3,305	10,267	20,477	42,213	69,053
Dwelling Units	34	34	672	1,311	3,786	6,852	13,882	22,021
Schools	0	0	0	0	0	5	8	10

EXHIBIT B-23

San Francisco International Airport

NOISE IMPACT SUMMARY

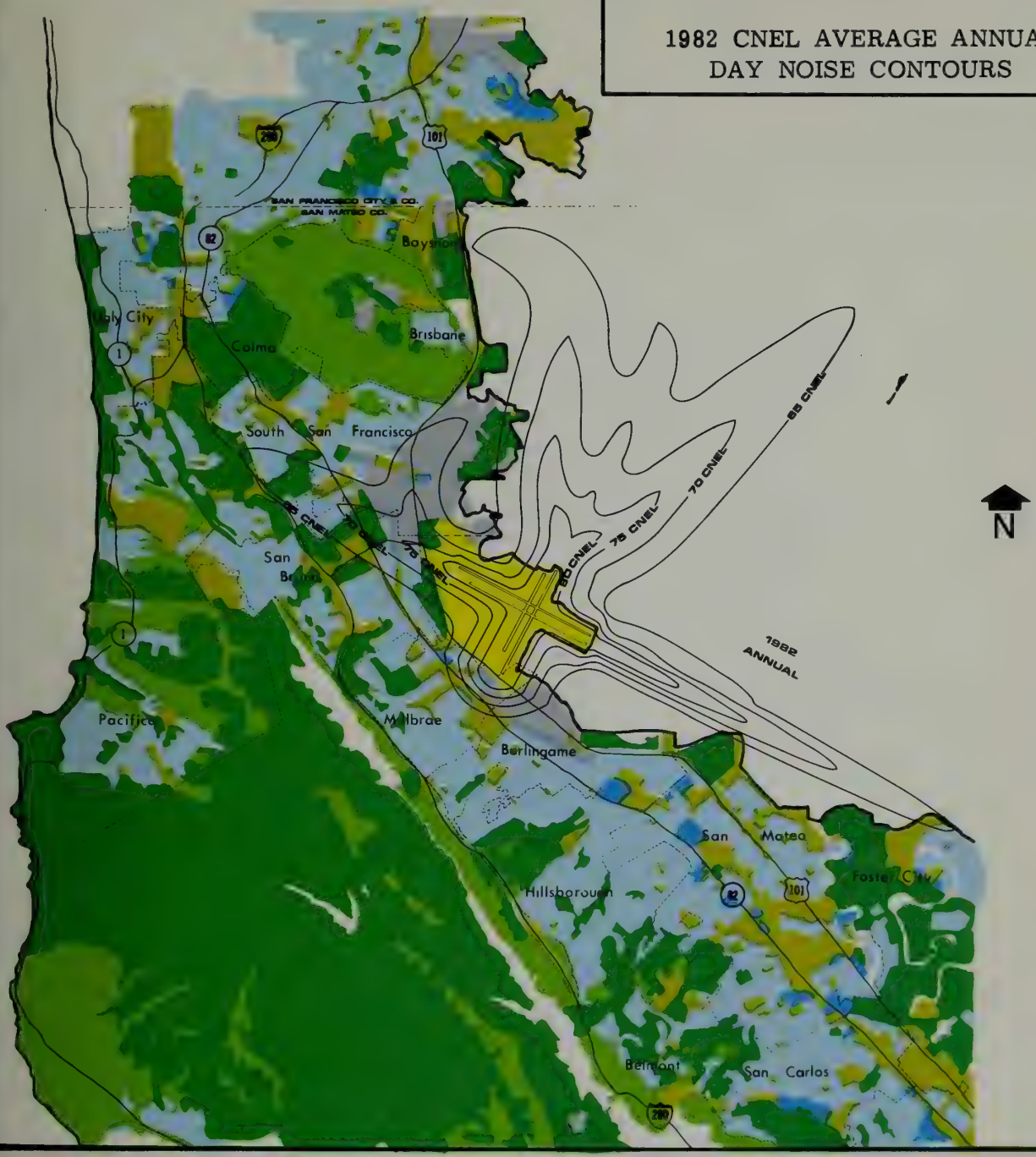
ASDS 1974

LAND USE CATEGORY (ACRES)	Within 10 Minutes		Within 5 Minutes		Within 1 Minute	
	Annual	Seasonal	Annual	Seasonal	Annual	Seasonal
Single Family Residential	145	171	169	421	515	1,275
Multi-Family Residential	0	4	6	17	17	17
Commercial	18	26	24	171	286	464
Industrial	141	323	316	849	1,140	1,180
Agriculture	0	0	0	0	0	0
Open Space	138	209	203	384	491	1,446
Airport	1,484	1,602	1,606	1,616	1,621	1,675
Total	1,926	2,335	2,324	3,458	4,070	6,057
POPULATION AND RESIDENCES						
People	4,444	5,402	5,442	13,415	16,019	44,157
Dwelling Units	1,729	2,068	2,072	4,573	5,413	13,761
Schools	0	0	1	3	3	7

EXHIBIT B-24

San Francisco International Airport

1982 CNEL AVERAGE ANNUAL
DAY NOISE CONTOURS



LEGEND

- San Francisco Intl. Airport
- Single Family Residential
- Multi-Family Residential
- Commercial
- Industrial
- Agriculture
- Open Space

EXHIBIT B-25

San Francisco International Airport

1982 CNEL AVERAGE SEASONAL DAY NOISE CONTOURS

LEGEND

- San Francisco Intl. Airport
- Single Family Residential
- Multi-Family Residential
- Commercial
- Industrial
- Agriculture
- Open Space

EXHIBIT B-26

San Francisco International Airport

1982 ASDS AVERAGE ANNUAL
DAY NOISE CONTOURS

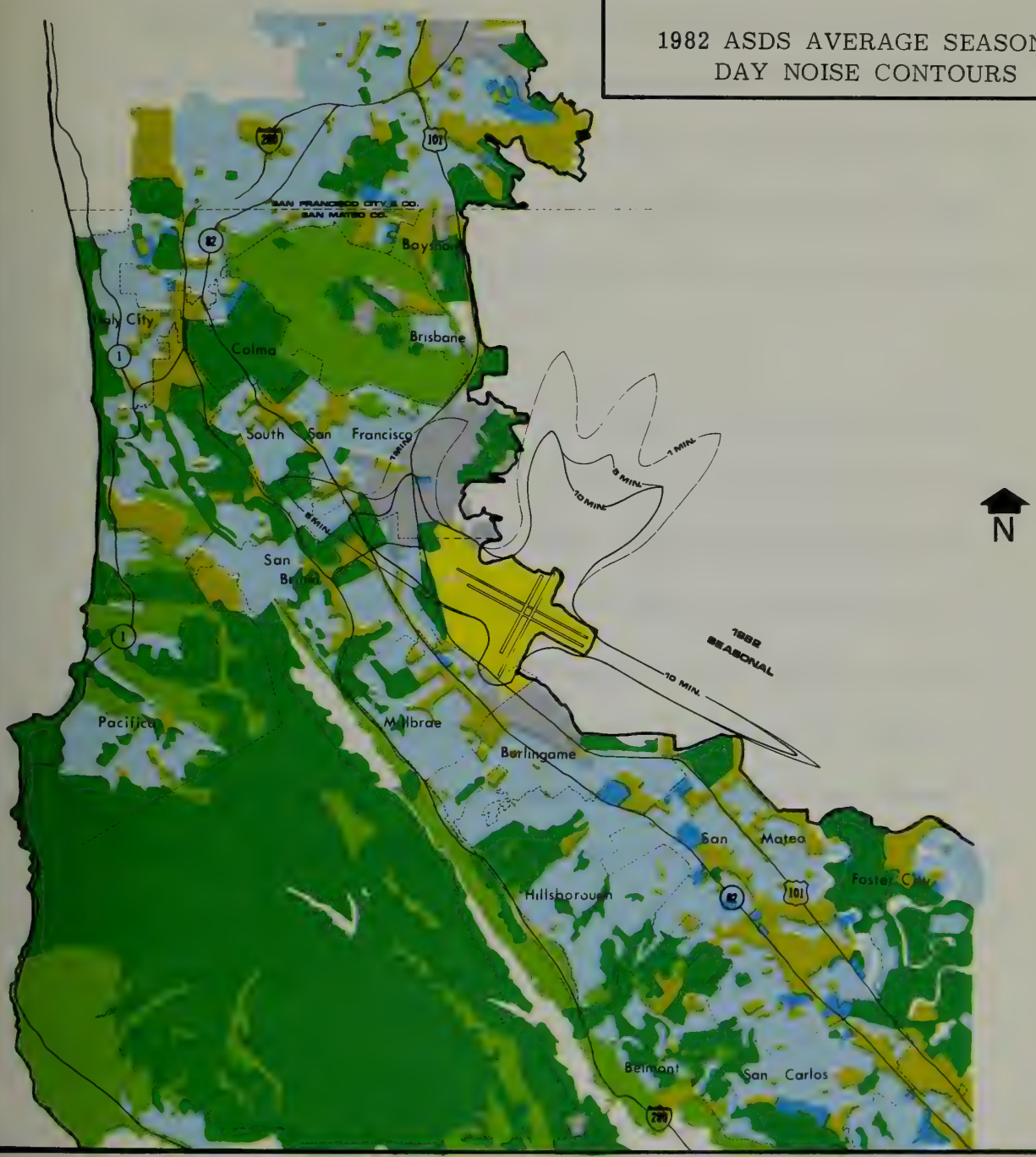
LEGEND

- San Francisco Intl. Airport
- Single Family Residential
- Multi-Family Residential
- Commercial
- Industrial
- Agriculture
- Open Space

EXHIBIT B-27

San Francisco International Airport

1982 ASDS AVERAGE SEASONAL
DAY NOISE CONTOURS



LEGEND

- San Francisco Intl. Airport
- Single Family Residential
- Multi-Family Residential
- Commercial
- Industrial
- Agriculture
- Open Space

The small increase in daily operations from 1974 to 1982 was offset by a higher proportion of quieter wide-bodied aircraft in the fleet mix. The net result was a decrease in the size of the 1982 CNEL and ASDS contours relative to the 1974 contours. The 65 CNEL contour along the 10-28 runways is approximately 17,000 feet shorter for both the annual and seasonal cases, while the ASDS one minute contour is approximately 27,000 feet shorter for both the annual and seasonal cases.

The noise impact summary for 1982 is shown in Exibits B-28 and B-29 for CNEL and ASDS respectively. For CNEL contours, the critical contour is 70 CNEL for 1982. There are approximately 211 acres of residential area within the 70 CNEL contour line for the annual case and 333 acres for the seasonal case. There are approximately 7,900 persons located within the 70 CNEL for the annual case and approximately 14,000 persons for the seasonal case. Homes within the 70 CNEL are approximately 3,000 and 5,000 for the annual and seasonal cases respectively. Most of the incompatible land area is located northwest of the airport near the San Bruno/South San Francisco areas.

The net reduction (for the annual case) in residential area encompassed by the 65 CNEL contour between 1974 and 1982 is 437

EXHIBIT B-28

San Francisco International Airport

NOISE IMPACT SUMMARY
CNEL 1982

LAND USE CATEGORY (ACRES)	Within 80 CNEL		Within 75 CNEL		Within 70 CNEL		Within 65 CNEL	
	Annual	Seasonal	Annual	Seasonal	Annual	Seasonal	Annual	Seasonal
Single Family Residential	9	0	53	50	211	333	815	1,554
Multi-Family Residential	0	0	0	0	0	17	17	17
Commercial	0	0	7	0	26	107	350	588
Industrial	15	0	58	113	314	731	1,233	1,793
Agriculture	0	0	0	0	0	0	0	5
Open Space	0	0	6	71	178	319	625	1,252
Airport	898	908	1,300	1,337	1,587	1,700	1,869	1,887
Total	922	908	1,424	1,571	2,316	3,207	4,909	7,076
POPULATION AND RESIDENCES								
People	299	0	1,734	1,614	7,827	13,878	29,646	60,623
Dwelling Units	124	0	719	670	2,999	5,050	10,237	20,291
Schools	0	0	0	0	0	1	5	10

EXHIBIT B-29

San Francisco International Airport

NOISE IMPACT SUMMARY
ASDS 1982

LAND USE CATEGORY (ACRES)	Within 10 Minutes		Within 5 Minutes		Within 1 Minute	
	Annual	Seasonal	Annual	Seasonal	Annual	Seasonal
Single Family Residential	101	160	158	413	421	416
Multi-Family Residential	0	0	0	4	17	17
Commercial	0	6	0	131	166	152
Industrial	74	280	208	339	866	873
Agriculture	0	0	0	0	0	0
Open Space	109	113	218	291	383	420
Airport	1,603	1,583	1,652	1,589	1,680	1,623
Total	1,887	2,146	2,236	2,767	3,533	3,501
POPULATION AND RESIDENCES						
People	3,315	5,404	5,104	13,410	14,751	14,355
Dwelling Units	1,368	2,148	2,055	4,835	5,193	5,109
Schools	0	0	0	0	3	3

acres, a reduction of approximately 34 percent. For the seasonal 65 CNEL contours, residential area is reduced 571 acres or 27 percent below 1974 levels.

The ASDS contours are smaller for 1982 than for 1974. Total residential area within the one minute annual contour decreases from 532 acres in 1974 to 421 acres in 1982, a reduction of 21 percent. For the seasonal case, residential area within the one minute contour is reduced by 842 acres, a reduction of 66 percent below 1974 levels.

(4) Impact Assessment for 1990

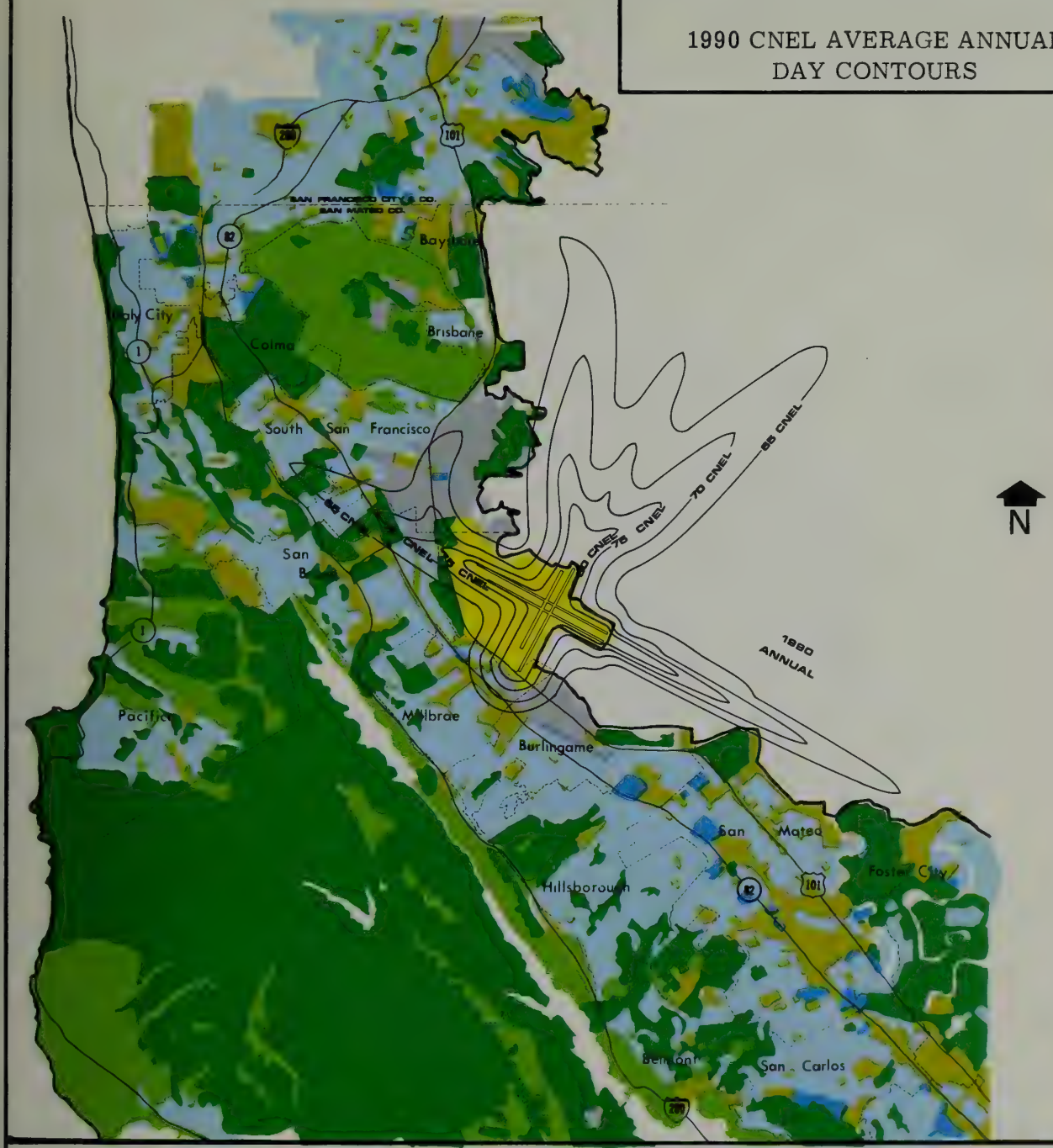
Annual and seasonal CNEL contours for 1990 conditions are shown in Exhibits B-30 and B-31 respectively. Exhibits B-32 and B-33 depict the ASDS annual and seasonal contours respectively. Due to a slight decrease in the aircraft operation levels and the assumption that all aircraft types would meet FAR Part 36 criteria by 1990, the noise contours encompass a smaller area than 1982 contours. The 65 CNEL contour along the 10-28 runway centerline is approximately 10,000 feet shorter in 1990 than in 1982. The one minute ASDS contour is approximately 1,000 feet shorter in 1990 than in 1982.

Exhibits B-34 and B-35 summarize the noise impact for CNEL and ASDS respectively. The 65 CNEL contour is the critical contour for 1990. A total of 481 acres of residential land is encompassed by

EXHIBIT B-30

San Francisco International Airport

1990 CNEL AVERAGE ANNUAL DAY CONTOURS



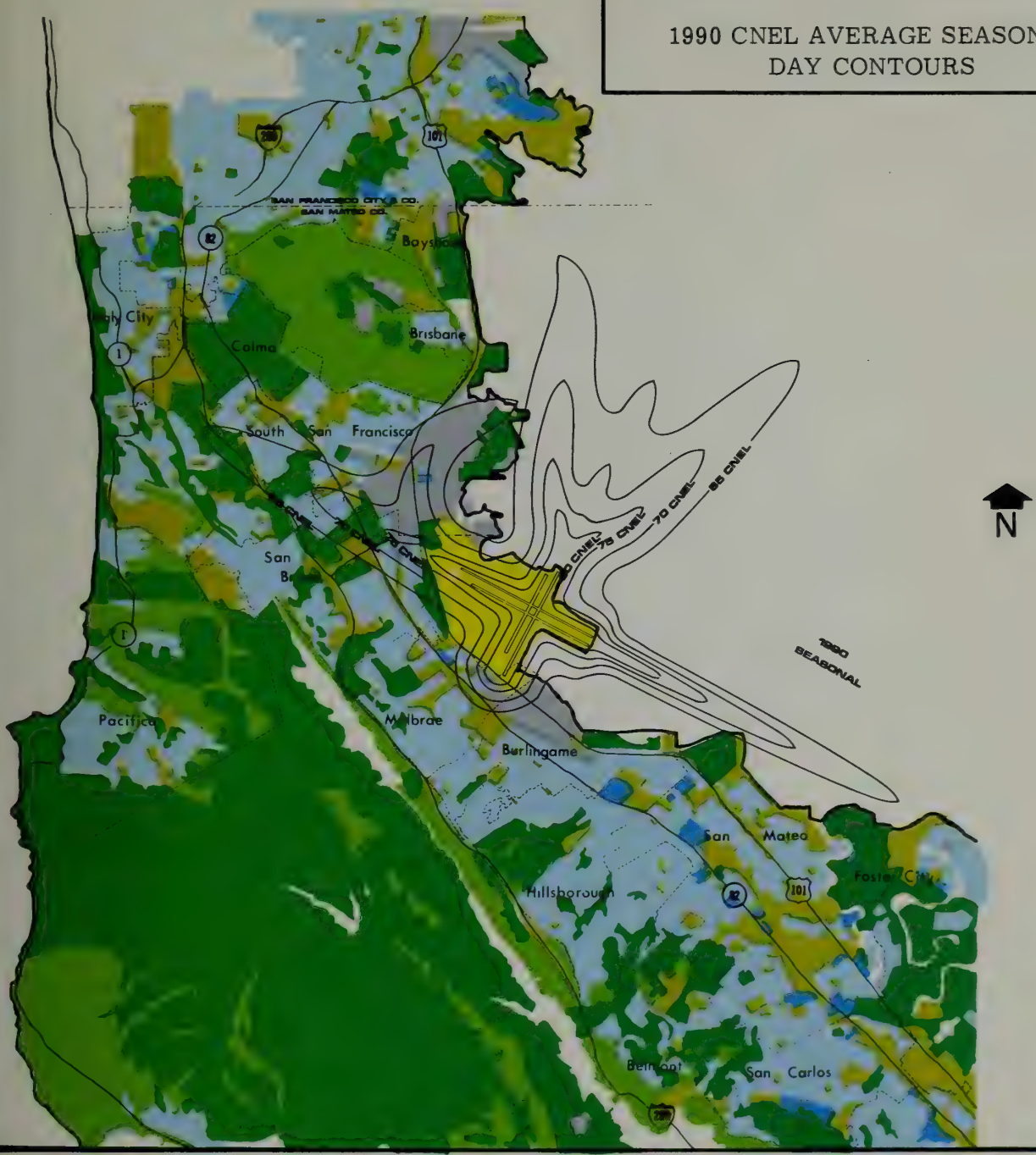
LEGEND

- San Francisco Intl. Airport
- Single Family Residential
- Multi-Family Residential
- Commercial
- Industrial
- Agriculture
- Open Space

EXHIBIT B-31

San Francisco International Airport

1990 CNEL AVERAGE SEASONAL DAY CONTOURS



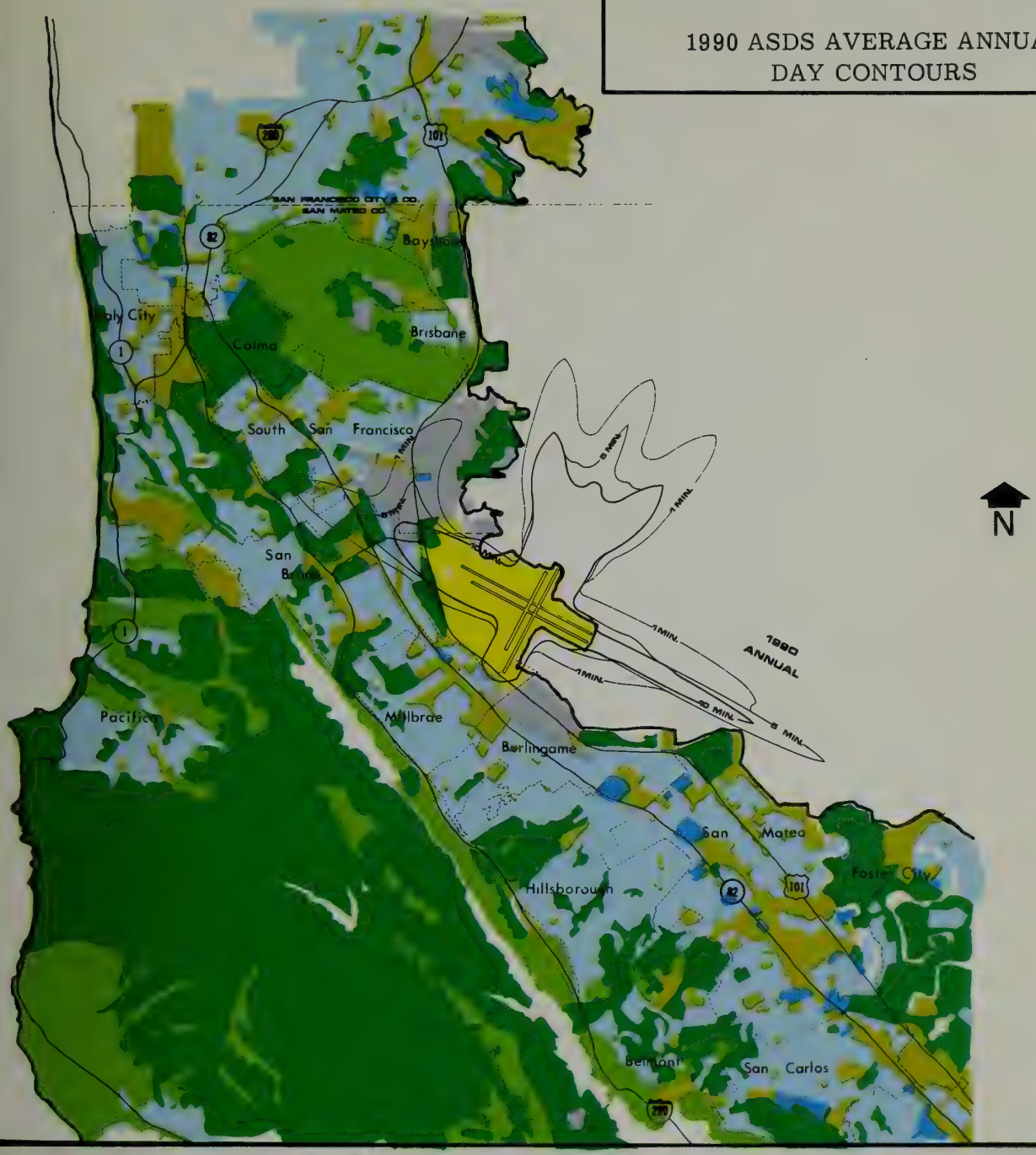
LEGEND

- San Francisco Intl. Airport
- Single Family Residential
- Multi-Family Residential
- Commercial
- Industrial
- Agriculture
- Open Space

EXHIBIT B-32

San Francisco International Airport

1990 ASDS AVERAGE ANNUAL DAY CONTOURS



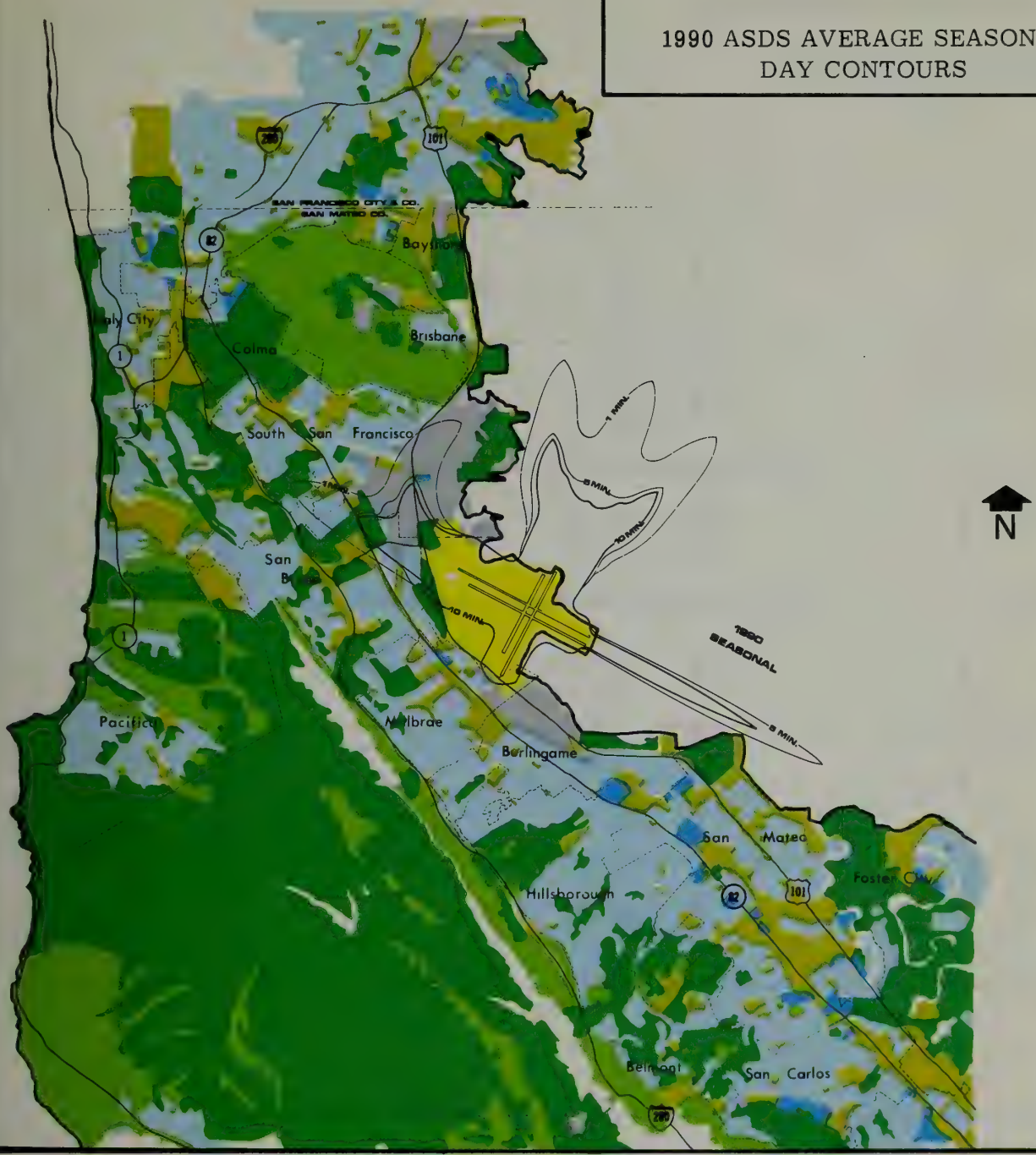
LEGEND

- San Francisco Intl. Airport
- Single Family Residential
- Multi-Family Residential
- Commercial
- Industrial
- Agriculture
- Open Space

EXHIBIT B-33

San Francisco International Airport

1990 ASDS AVERAGE SEASONAL DAY CONTOURS



LEGEND

- San Francisco Intl. Airport
- Single Family Residential
- Multi-Family Residential
- Commercial
- Industrial
- Agriculture
- Open Space

EXHIBIT B-34

San Francisco International Airport

NOISE IMPACT SUMMARY
CNEL 1990

LAND USE CATEGORY (ACRES)	Within 80 CNEL		Within 75 CNEL		Within 70 CNEL		Within 65 CNEL	
	Annual	Seasonal	Annual	Seasonal	Annual	Seasonal	Annual	Seasonal
Single Family Residential	0	0	13	50	131	278	464	925
Multi-Family Residential	0	0	0	0	0	13	17	17
Commercial	0	0	0	0	19	62	183	285
Industrial	3	1	26	50	225	469	819	1,416
Agriculture	0	0	0	0	0	0	0	0
Open Space	0	0	0	32	69	246	145	690
Airport	745	846	1,066	1,203	1,379	1,635	1,697	1,809
Total	748	847	1,105	1,335	1,823	2,703	3,325	5,142
POPULATION AND RESIDENCES								
People	0	0	445	1,712	4,500	10,348	17,205	35,231
Dwelling Units	0	0	187	719	1,891	3,886	6,357	8,427
Schools	0	0	0	0	0	1	3	7

EXHIBIT B-35

San Francisco International Airport

NOISE IMPACT SUMMARY

ASDS 1990

LAND USE CATEGORY (ACRES)	Within 10 Minutes		Within 5 Minutes		Within 1 Minute	
	Annual	Seasonal	Annual	Seasonal	Annual	Seasonal
Single Family Residential	69	157	134	174	382	417
Multi-Family	0	0	0	0	17	17
Commercial	0	0	0	1	123	145
Industrial	137	205	197	283	783	777
Agriculture	0	0	0	0	0	0
Open Space	85	186	175	205	353	351
Airport	1,498	1,610	1,606	1,619	1,628	1,628
Total	1,789	2,150	2,112	2,282	3,286	3,335
POPULATION AND RESIDENCES						
People	2,430	5,340	4,641	5,940	14,077	15,085
Dwelling Units	1,006	2,179	1,902	2,431	5,069	5,446
Schools	0	0	0	1	3	3

the 65 CNEL contour for the annual case and 942 acres for the seasonal case. For the annual case, approximately 17,200 persons are located within the 65 CNEL and approximately 6,400 dwellings. For the seasonal case, approximately 35,200 persons and 12,300 homes are enclosed by the 65 CNEL contour. Total acreage within the 65 CNEL annual contour decreases from 4,909 acres in 1982 to 3,325 acres in 1990, a reduction of 32 percent. Acreage within the 65 CNEL seasonal contour decreases from 7,076 acres in 1982 to 5,142 acres in 1990, a reduction of 27 percent.

Residential area located within the one minute ASDS annual contour decreases approximately 51 acres from 1982 to 1990, a reduction of approximately 12 percent. For the one minute seasonal contour, residential acreage remains the same from 1982 to 1990.

(5) Mitigating Measures

Community exposure to aircraft noise, in future years, at SFIA is reduced below existing levels. There is no difference between the noise impact of the "do-nothing" alternative and the noise impact of the proposed terminal complex development alternative. Thus the proposed development program would not produce any degradation in community noise environment that would not otherwise occur if the development program were not implemented. Therefore, measures to mitigate noise pollution caused by the development action are not required since no such pollution is anticipated.

Noise pollution will in fact be reduced over time at SFIA through various mitigating measures, but these mitigating measures are not related to the development program at the airport. It is instructive to examine the measures available for noise control at SFIA.

Aircraft noise can generally be abated through four control options (7):

- Source control options
- Path control options
- Receiver control options
- Land use control options

Source control options refer to programs such as the retrofit and quiet nacelle programs as well as the development of quieter engines on the new generation of wide-bodied aircraft. Path control options refer to programs such as the proposed "two-segment approach" and curved approaches which would be possible with the installation of the microwave landing system (MLS). Receiver options refer to such programs as preferential runway use and curfew agreements. Land use control options generally refer to the purchase of noise impacted areas.

Mitigating measures related to source control of aircraft noise have been incorporated in the analysis for SFIA. Modified noise characteristic curves were used in the 1982 and 1990 analysis and

are the primary reason for the reduction in the overall area encompassed by the noise contours. This type of mitigating measure would result independently of the SFIA expansion program and the degree of amelioration is a function of the speed with which the various quiet engine programs proceed.

The two segment approach path control option is a potential mitigating measure for noise abatement. The two segment approach will allow aircraft to make the final approach at higher altitudes thus reducing the noise exposure at ground level. Like source control options, mitigation from the two segment approach would occur independently of the SFIA development program.

Receiver control options as a mitigating measure, have met with positive success at SFIA. As a result of litigation that was settled out of court in 1971, the airport has taken a number of major steps to lessen the noise problem. These are:

- Lengthening of runway 28R, which makes possible right turns short of San Bruno Mountain on takeoffs to the west and in turn reducing the number of flights that must fly through the "Gap" over South San Francisco.

- Maximizing use of runways 1L and 1R. By allowing higher crosswind components, more aircraft can take off on runways 1L and 1R, over water.

- The FAA and SFIA have examined the possibility of routing flights farther to the east, maximizing of over water approaches. In addition, a number of approach and departure procedures have been developed to minimize noise effects.

- SFIA is in the process of installing a continuous noise monitoring system which will provide definitive identification of noise impacted areas.

- A Sound Abatement Center has helped maintain a public forum for the noise impacted residents, SFIA and the airlines.

The ameliorative effects of lengthening runway 28R and shifting more flights to runways 1L and 1R have been incorporated in this analysis.

Land use control options as a mitigating measure at SFIA have not been fully explored, and for good reason. Due to the extreme urbanization and residential development that has occurred close to the airport over the years, the cost of land use control, i.e., acquisition of impacted areas, would be prohibitively expensive.

Positive benefits in noise reduction can and will accrue to the residents near SFIA. These benefits are more a function of time, various regulatory agencies, and private industry and not a function of the proposed airport development program.

(6) Summary and Conclusions

The proposed airport development program will not produce greater levels of noise exposure than would occur without

the expansion program. In fact, the magnitude of noise impact from aircraft operations is independent of the expansion program, since operations levels and fleet mix characteristics are insensitive to the proposed developed program.

Exhibits B-36 and B-37 graphically depict the magnitude of noise impact over time in the language of the CNEL and ASDS descriptor systems respectively. These exhibits show residential acres (the incompatible land use prescribed by California law), persons, and dwellings within the various contours. No ASDS criterion presently exists for determination of compatible land. Exhibit B-38 presents the noise impact in tabular form and shows the rates of increase or decrease of noise impacted areas.

The total residential area encompassed by the noise contours (represented by the 65 CNEL contour and the one minute ASDS contour) decreases over time. This decrease is attributed to a higher percentage of quieter aircraft types expected to be in use at SFIA in the future. Further decreases in noise levels can be expected with implementation of the two-segment approach and microwave landing systems. Since the California compatible land use criterion becomes stricter in the future (80 CNEL for 1974, 70 CNEL for 1982 and 65 CNEL for 1990) the number of incompatible residential acres increases over the years. Likewise, the number of people and dwellings within

EXHIBIT B-36

San Francisco International Airport

CNEL SUMMARY

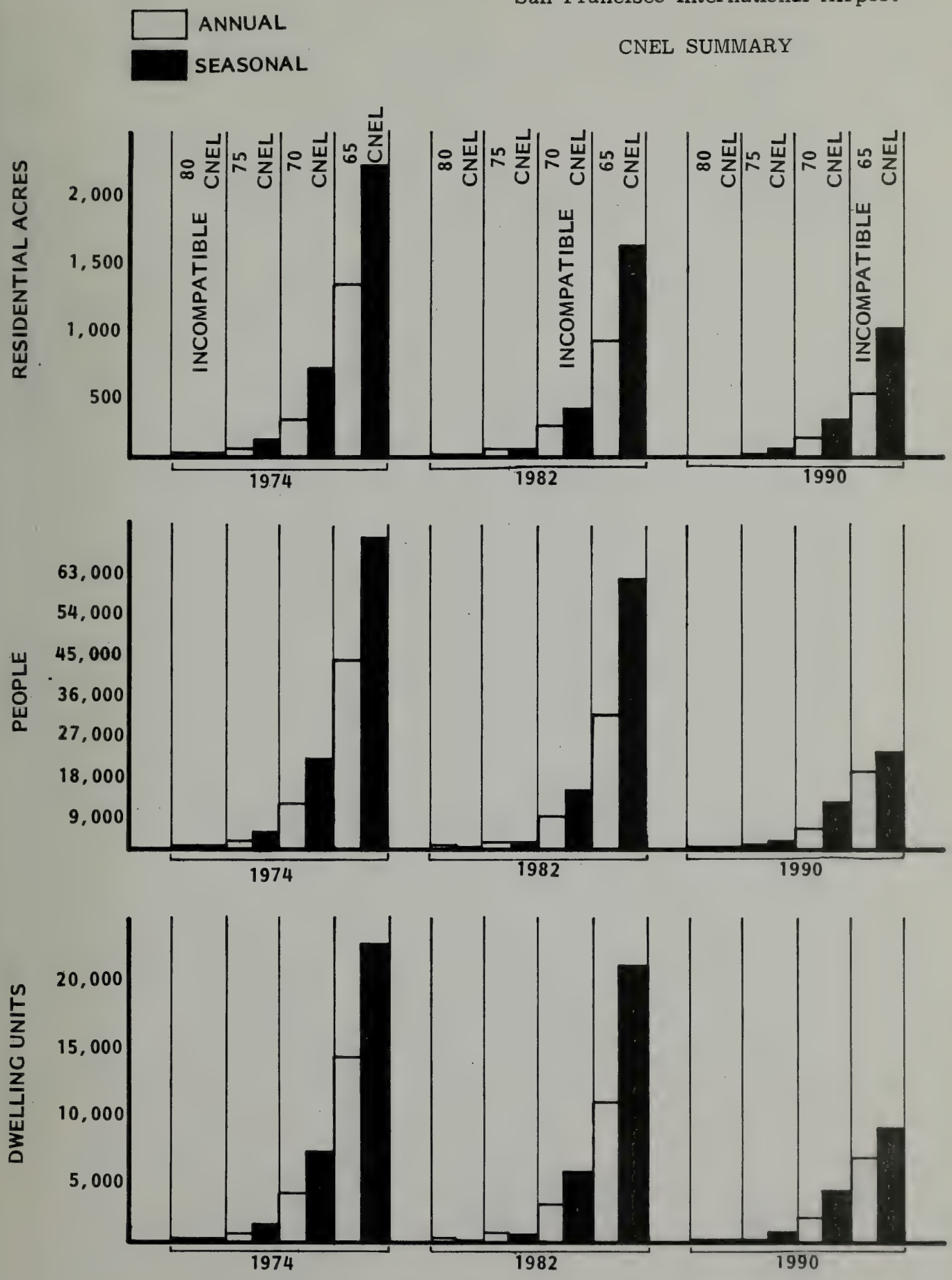


EXHIBIT B-37

San Francisco International Airport

ASDS SUMMARY

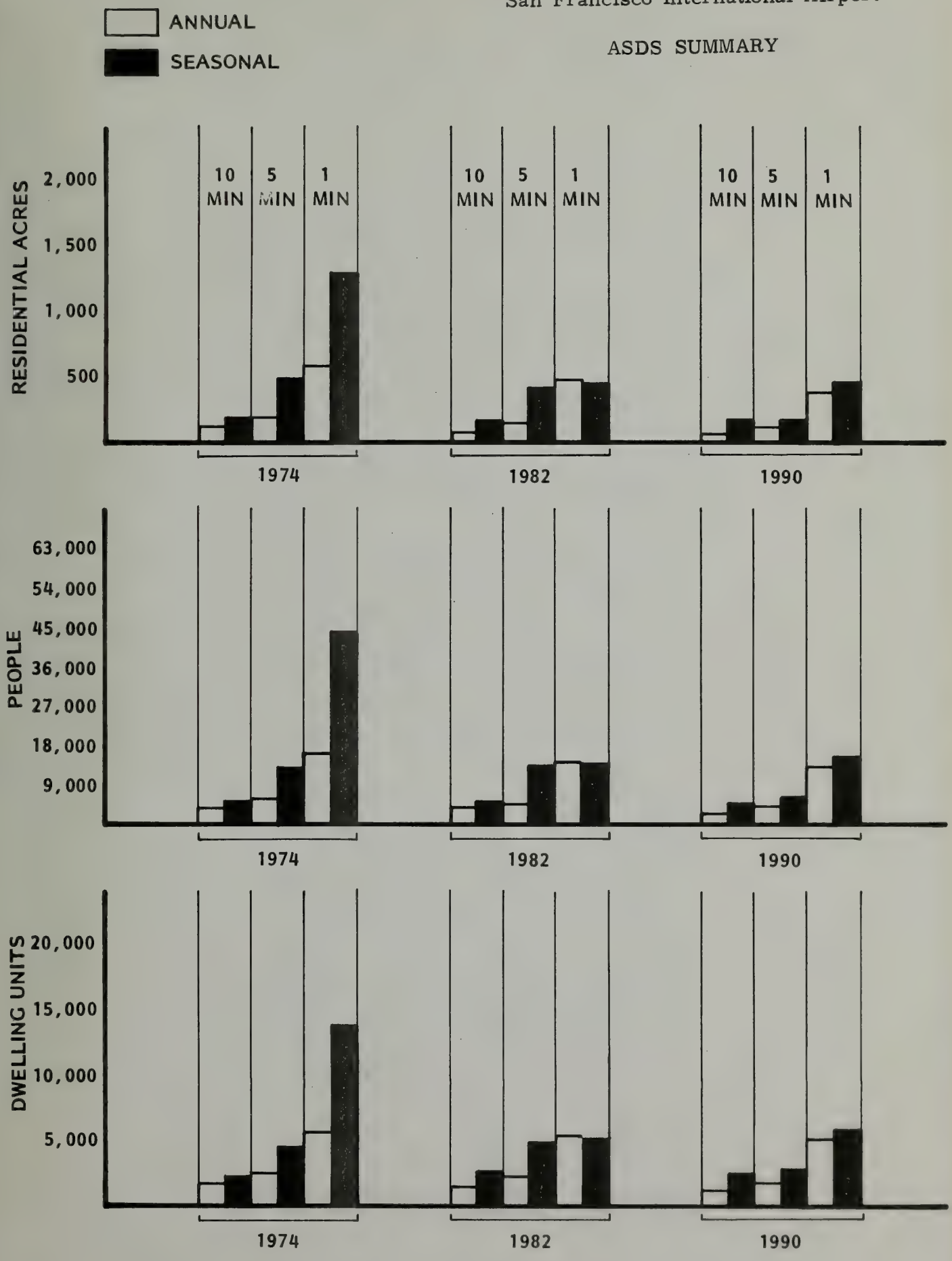


EXHIBIT B-38

San Francisco International Airport

NOISE IMPACT SUMMARY

	CNEL (Acres)						ASDS (Acres)			
	Incompatible Area		Total Residential Area		Total Area		Total Residential Area		Total Area	
	Annual	Seasonal	Annual	Seasonal	Annual	Seasonal	Annual	Seasonal	Annual	Seasonal
1974	3	3	1,269	2,142	6,338	8,768	532	1,292	4,070	6,057
1982	211	350	815	1,554	4,909	7,076	438	433	3,532	3,501
Percent Change 1974-1982	+7000%	+11600%	-36%	-27%	-23%	-19%	-18%	-66%	-13%	-45%
1990	481	942	481	942	3,325	5,142	399	434	3,286	3,335
Percent Change 1982-1990	+228%	+269%	-41%	-39%	-32%	-27%	-9%	0%	-7%	-5%

the designated incompatible residential areas increases as do the number of schools. However, this will be the case whether or not the proposed terminal complex expansion plan is implemented.

Various mitigating measures have been or will be in effect that serve to reduce the noise impact, although none of these measures is directly related to the proposed project. The airport has lengthened runway 28R which allows a higher percentage of takeoffs on 28R to turn out over the water. The allowable crosswind component for operations on the 1-19 runways has been increased, which permits more landings and takeoffs over water. (Both of these have been incorporated in the analysis). Finally, the airport is in the process of installing a continuous noise monitoring system with the objective of measuring day to day noise exposure due to aircraft operations and identifying specific solutions to specific problem areas.

References - Appendix B

Reference No.	Title
1	Public Law 85-726 - Federal Aviation Act
2	Public Law 90-411 - Aircraft noise and sonic boom
3	Public Law 91-190 - National Environmental Policy Act
4	Public Law 91-258 - Airport Development Aid Program
5	Public Law 91-604 - Noise Pollution and Abatement Act
6	Public Law 92-574 - Noise Control Act
7	Review and Analysis of FAA noise regulation NTID 73.6 - EPA, July, 1973
8	Title 4 - Subchapter 6 - Noise Standards, Department of Aeronautics, State of California
9	"Resolution No. 7467 - A Five Point Plan for Airport Noise Abatement," Board of Airport Commissions, Los Angeles International Airport, December 20, 1972
10	"NBAA Noise Abatement Programs" L.P. Bedore, National Business Aircraft Association, Inc., March, 1973
11	"ATA Flight Operations Committee Recommended Takeoff Procedures - Effective Date 1 August, 1972," Operations Memorandum No. 72-64, W. A. Jenson, Air Transport Association of America, June, 1972
12	"Regarding PSA Policies Involving Noise Abatement During Arrivals and Departures," R.E.L. Carmichael, Pacific Southwest Airlines, March, 1973
13	A Digital Computer Program for Computation of Noise Exposure Forecast Contours, Bolt Beranek and Newman, June, 1970

Reference No.	Title
14	Aircraft Sound Description System, J. E. Cruz, FAA Report No. FAA-EQ-73, March, 1973
15	Jeppeson Airway Manual
16	Atlas of Urban and Regional Change, San Francisco Sheets: 150-525, 175-550, 150-550, 125-550, 150-575, 125-575, Department of Interior, U. S. Geological Survey, May, 1970
17	Summary of Series 2 Projections, ABAG/MTC, August, 1973

APPENDIX C

GROUND ACCESS

APPENDIX C

GROUND ACCESS

The rugged topography which makes San Francisco a picturesque city and makes its residents rightfully guarded against any change which might infringe upon the quality of life is also the underlying reason for the need for optimizing use of the available transportation facilities. The San Mateo County Peninsula is perhaps the area's prime example of the constricting geographic influence on travel flows. Its six-mile width tends to concentrate travel into and through the Peninsula and San Francisco onto a few major facilities. The location of the San Francisco International Airport on this strip between the ocean and the bay is one of the factors which caused the Federal Aviation Administration to request of the Airport Commission this detailed analysis of the ground access impacts as they relate to the future growth in air travel anticipated for San Francisco International Airport.

1. INTRODUCTION

Within the past year, fuel shortages, the general economic condition and concerns for the environment have changed what has been a secular trend of constantly increasing vehicular traffic in the bay area. The result is new to San Francisco - - no net increase in vehicular traffic flows generally in the region and particularly in the vicinity of the airport. Air travel growth has likewise slowed as documented in other sections of this impact assessment.

Purpose and Scope

The specific purpose of the ground access element of this impact assessment is to identify and measure the ground travel demands associated with present and future levels of air travel, compare those demands to available and projected ground access capacities and assess the consequences as they relate to relative congestion levels, delays, and other travel impacts on airport access facilities, roadways in the immediate vicinity of the airport and parking needs.

To accomplish these objectives, ground transportation analyses were performed for three levels of air passenger travel demands, as follows:

16.2 million annual air passengers in 1974

24.4 million annual air passengers in 1982

31.0 million annual air passengers in 1990.

Correlation of air passenger levels with future years is a necessity since non-airport travel demands on the roadway system are far more significant in terms of regional consequences. Having established regional travel volumes for these time periods, it was possible to assess the impact of airport-related travel with and without the expansion of airport facilities and, at the same time, test the effects on 1990 travel under the assumption that rapid transit service would be available as an extension from Daly City to San Francisco International Airport.

Data Collection

The fulfillment of the objectives enumerated above is predicated on the development of a comprehensive and accurate data base. To develop that data base, several steps were undertaken. First, for reasons of obvious economy, a careful review and evaluation was conducted of available data related to travel patterns, traffic volumes and the capacity of the existing transportation

system. All data obtained from secondary sources were verified and evaluated. These data included geometric configuration of the existing highway system, recent traffic count information, parking inventories and roadway signing/ regulatory data. In addition to highway-related information, all public transportation services (including taxicab service) were interviewed and data were collected on methods of operation, patrons carried, schedules of service, routings and access points, dwell times at curb space, etc.

Another important element of the inventory included employee-related data on travel characteristics, mode of travel and parking requirements. Finally, ancillary services were inventoried including ground needs for cargo, rental car service, and hotel/motel facilities. These "secondary source" data were collected and evaluated not only for present conditions but for available projection periods. The review of these data indicated needs for new information which resulted in a data collection effort, as follows:

- round-the-clock automatic traffic recorder counts at 10 locations
- manual turning movement/vehicle classification counts for a typical weekday (January 10, 1975)
- scale drawings of intersections to establish geometric configurations
- speed and delay runs (at peak and off-peak periods) on major roads in the airport vicinity
- inventory of posted speed limits, traffic characteristics and control devices
- special parking studies

This data collection effort permitted the closing of all major gaps in the data base and assured an inventory of information which would provide a convenient base for estimating future conditions.

2. ACCESS FACILITIES

San Francisco International Aiport is located on the west side of San Francisco Bay, approximately 15 miles south of downtown San Francisco (Exhibit C-1). This location in the middle of the San Mateo County Peninsula effectively limits ground access to a few principal external approach routes. The main access facility is the Bayshore Freeway (U. S. 101) which connects the metropolitan areas of San Francisco and San Jose, passing within one-half mile of the terminal buildings. Access to the airport property from this four-lane freeway is provided by a directional interchange which gives exclusive connection to the airport terminals, offices, parking areas and related facilities. Secondary external links include South Airport Boulevard which intersects the Bayshore Freeway interchange at San Bruno Avenue and Old Bayshore Highway which intersects the Freeway at Millbrae Avenue.

Public transit plays a major role in transporting air travelers to downtown San Francisco. Passenger surveys indicate that almost half the air travelers with downtown origins and destinations utilize this mode of access. Airporter Bus runs 24-hour, direct service between the

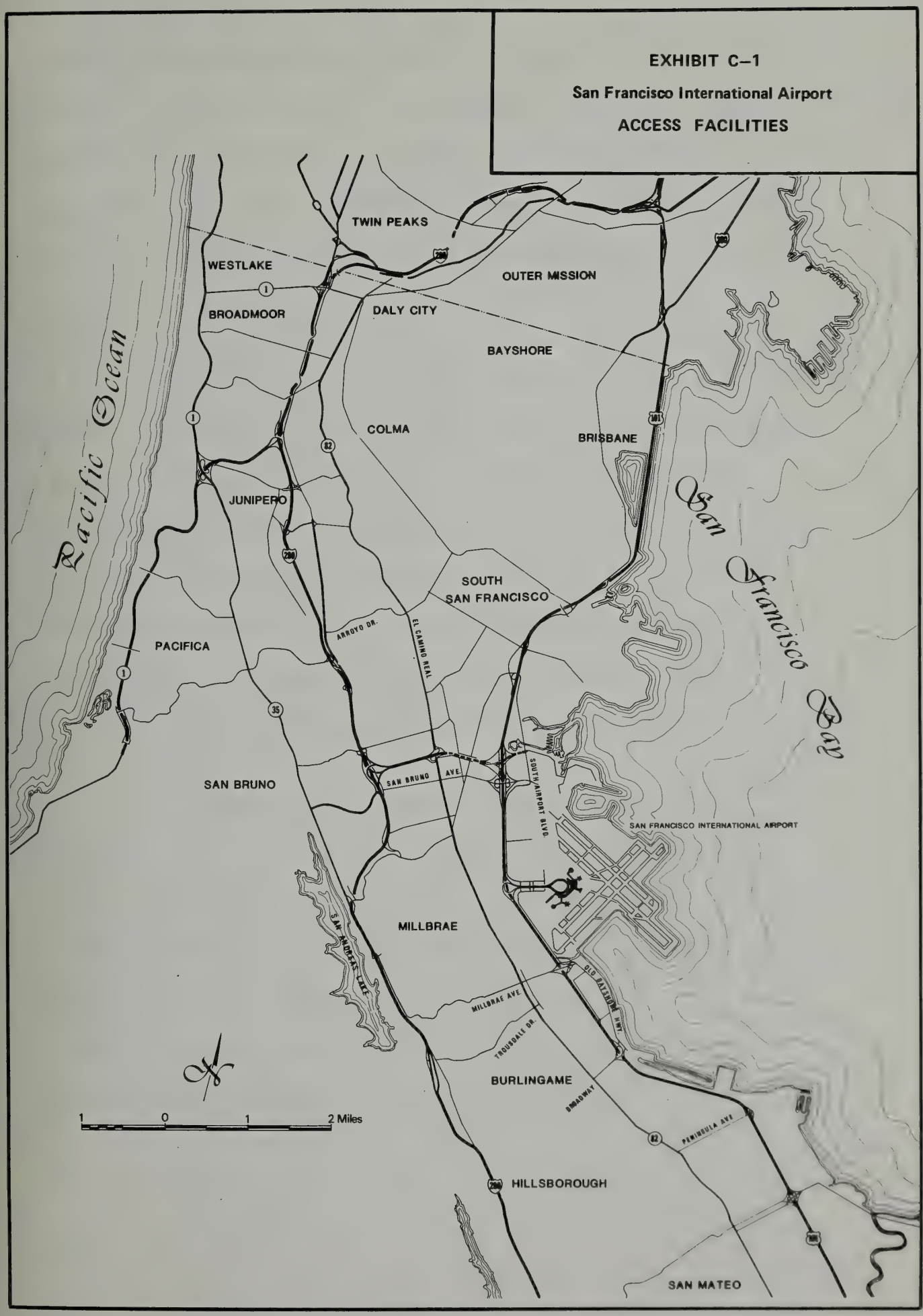


EXHIBIT C–1
San Francisco International Airport
ACCESS FACILITIES
Pacific Ocean
San Francisco Bay
TWIN PEAKS
WESTLAKE
OUTER MISSION
BROADMOOR
DALY CITY
BAYSHORE
COLMA
BRISBANE
JUNIPERO
SOUTH SAN FRANCISCO
PACIFICA
ARROYO DR.
EL CAMINO REAL
SAN BRUNO
SAN BRUNO AVE
SOUTH AIRPORT BLVD.
SAN FRANCISCO INTERNATIONAL AIRPORT
MILLBRAE
SAN ANDREAS LAKE
OLD BAYSHORE HWY.
MILLBRAE AVE
TROUSDALE DR.
BURLINGAME
BROADWAY
PENINSULA AVE
HILLSBOROUGH
SAN MATEO
1 0 1 2 Miles

airport and the downtown terminal at Taylor and O'Farrell Streets. These buses make approximately 110 daily trips each way operating every 15 minutes during most of the day with 30-minute service provided in the late evening. Buses make the 20-25-minute trip utilizing the Bayshore Freeway at a fare of $1.15.

In addition to this major service to downtown San Francisco, Airporter also provides four daily trips to the Continental Trailways Terminal in downtown Oakland with intermediate stops at Oakland Army Base and Treasure Island. Southbound service is provided by two daily trips between downtown San Jose and the airport with an intermediate collection point at San Jose Municipal Airport. Some service is provided between Palo Alto and the airport.

In addition to Airporter bus, public transit service is also provided by Greyhound from their downtown San Francisco depot on 7th Street. However, unlike Airporter, Greyhound service is primarily a commuter operation between San Francisco and Redwood City with the airport being a relatively minor purpose for this service. The service is provided on a 20-minute headway at a fare of $1.10.

Taxicabs are, of course, available for air travelers. This personalized service has a commensurately higher price with an average trip to San Francisco being about $12.00. There are no rail transit facilities which presently serve the airport. The Southern Pacific does provide commuter service along the Peninsula but has no stations in the airport vicinity.

Internal Circulation System

Internal circulation at SFIA may be viewed in three parts - - the major east-west roadway connecting the Bayshore with the terminal buildings; the frontage road system along the Bayshore; and minor roadways connecting to maintenance facilities, hotels, parking lots, etc. All traffic destined for the airport off the Bayshore Freeway passes through the eight-lane divided roadway connecting to the parking garage and enplaning/deplaning circulator roads. The frontage road is a continuous facility running from south of the Broadway interchange (as Old Bayshore Highway) across the airport property and north (as South Airport Boulevard) into the South San Francisco Industrial Park. This is the principal distributor road for maintenance and cargo facilites, hangars, office facilities and employee parking. Minor

roadways intersect with the frontage road and provide connections to employee parking lots and buildings. These include the north access road running along the north edge of the United Airlines maintenance base to the Coast Guard Station. Also, this roadway serves the Post Office Air Mail facility and hangars. Two other roadways parallel the main airport entrance and serve employee parking lots, air cargo buildings, hangars and service areas near the terminal.

Parking

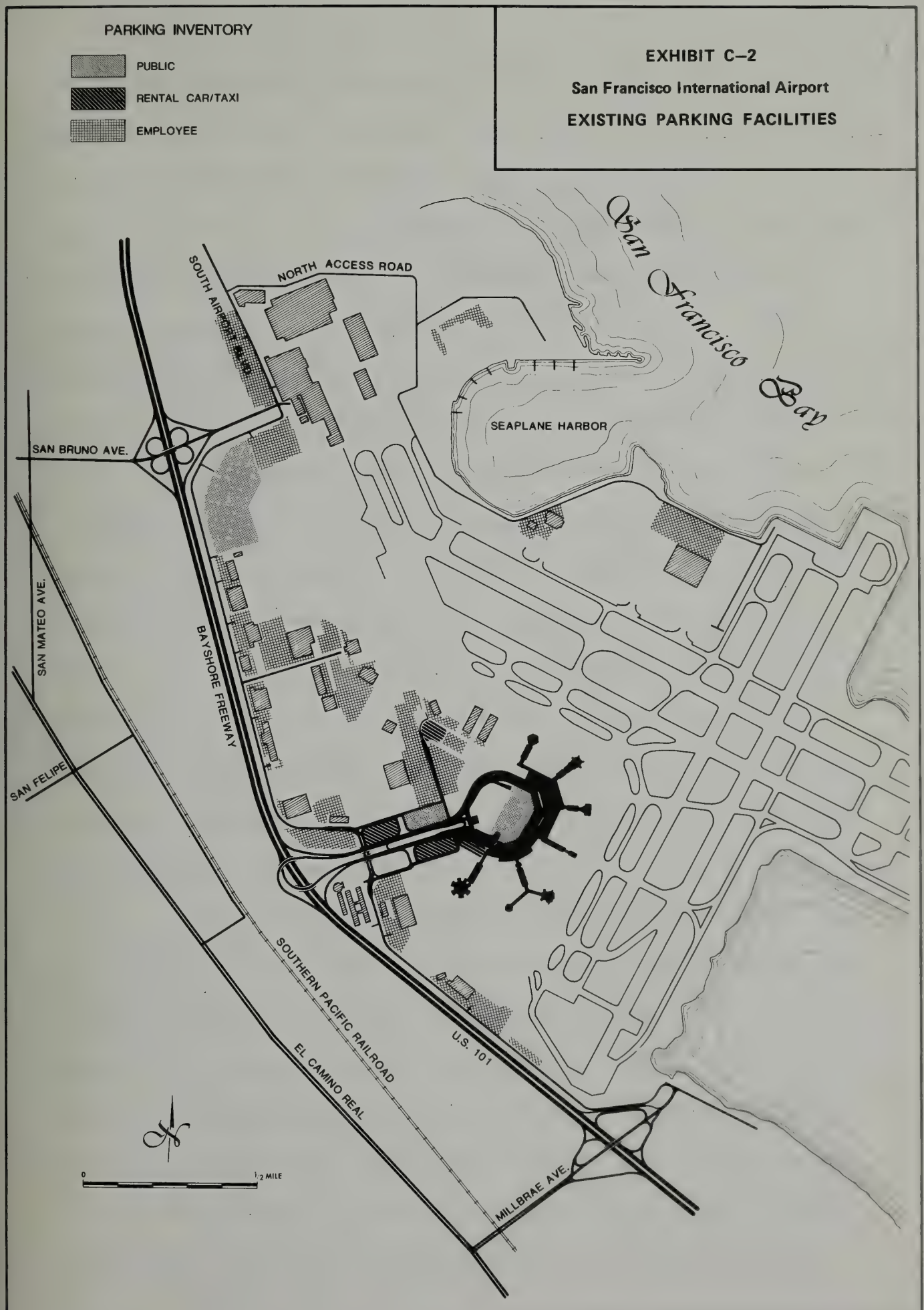
Parking on the airport property serves a variety of purposes. Air passengers, visitors, employees, rental cars, trucks, service vehicles, taxicabs, limousines and hotel guests comprise a cross-section of the users of airport parking facilities. Major parking for air travelers is provided in the 3,100-space garage directly opposite the terminal buildings. In addition, there is a 2,600-space remote facility adjacent to the San Bruno Avenue interchange which connects air travelers to the terminal through an airport-operated shuttle bus service along Airport Boulevard. In the main terminal area, the shuttle bus also services a 340-space public parking lot (B) and two employee lots (C and 2) providing 360 and 840 spaces, respectively. Tenant employee parking is located in relation to buildings spread

over the airport property. Rental cars are parked in two lots adjacent to the main access roadway. There are privately owned remote parking facilities which include Park-n-Fly service adjacent to the South Airport Boulevard interchange north of the airport and Anza Corporation's facility south of the airport near the Old Bayshore Highway intersection. Altogether, there are more than 6,000 spaces available for air travelers and visitors with almost 12,000 employee parking spaces within the airport property (Exhibit C-2).

3. METHODOLOGY

To achieve the objective of developing reliable systems of airport-related traffic under future levels of air travel, it is necessary to develop and test a simulation methodology. The basic technique involves establishment of actual conditions, segregating the various elements of that actual market, relating those elements to given future conditions of air travel, related traffic and employee-generated travel, then comparing the "constructed" numbers against actual traffic volumes counted on survey day. Once the simulation technique is established and verified, the next step in the process relates to comparing roadway volumes against capacities to locate and quantify existing or potential problem areas.

Ground access to the airport involves the travel patterns of three basic groups: air passengers, non-air


PARKING INVENTORY
PUBLIC
RENTAL CAR/TAXI
EMPLOYEE
EXHIBIT C–2
San Francisco International Airport
EXISTING PARKING FACILITIES
San Francisco Bay
NORTH ACCESS ROAD
SOUTH AIRPORT ACCESS
SEAPLANE HARBOR
SAN BRUNO AVE.
SAN MATEO AVE.
BAYSHORE FREEWAY
SAN FELIPE
SOUTHERN PACIFIC RAILROAD
EL CAMINO REAL
U.S. 101
MILLBRAE AVE.
0
1/2 MILE

passengers and airport employees. Each of these markets exhibits separate and distinguishable characteristics with respect to tripmaking and modal choice. An air passenger, for the purpose of this analysis, is an enplaning or deplaning traveler who requires ground transportation. The ground access analysis is not concerned with the 12.2% of all air passengers who transfer between planes and, therefore, remain within the terminal complex. Non-air passengers comprise that group of travelers who serve air passengers (by pick-up or drop-off), persons having business at the airport and any casual visitors coming to or from the airport. The airport employee group is the total number of persons regularly employed on the airport property during a typical 24-hour period. This category includes airline customer service personnel, airline maintenance employees, airport employees, government employees (e.g., Post Office personnel), hotel/motel employees and others.

The survey day data collection effort described in the introduction to this appendix provided specific travel pattern information for these subgroups. These data supplemented by "secondary source" information, created the data base for tripmaking and modal choice characteristics. The simulation involved the translation of these travel characteristics of each subgroup into the vehicular trips by mode. The first step in this process involved the estimation of total

person trips based on ratios of trips per person relating survey day ground counts to numbers of air travelers, parkers and employees. Following the establishment of overall trip generation rates, travelers were split into separate modes by disaggregating tripmaking first into two basic components: 1) the terminal area, and 2) the remainder of the airport complex. This effectively subdivides travel into air passenger/non-air passenger and employee/truck travel. Having established the present mode split for these groups fixed the future estimates of mode split for those test options where the supply of highway and public transport services remained in balance with 1974 conditions (e.g., the cases where rapid transit services are not provided).

Having established the trip generation rates for air passenger and employees and the mode split from base year data, person trips were converted to vehicular travel using the occupancy rates indicated in Exhibit C-3. These vehicle trips were distributed from their point sources on the basis of minimum travel time paths, or in the case of public transit vehicles, their assigned routes. Underlying this distribution process are a number of assumptions about travel patterns at the airport. These include:

EXHIBIT C-3

San Francisco International Airport

VEHICLE OCCUPANCY RATES

	Enplaning		Deplaning
Air Passengers:			
Private Car (Air Passenger Only)	1.30		1.30
Serve Passenger Auto	1.45		1.45
Rental Car	1.30		1.30
Taxi	1.45		1.90
Employees:			
Basic Terminal Employees		1.30	
Employees at UAL Maintenance Base		2.10	
Casual Visitors:			
Business		1.43	
Social		2.24	
Other		1.75	
Serve Passengers		2.0	

- Air travelers/visitors make their inbound-outbound trips via the same mode -- it is reasonably obvious that an air traveler would not drive to the airport and take a bus when he returns.
- The majority of travelers use the same access highways and internal roadways for inbound and outbound trips.
- Truck traffic does not display this characteristic of symmetry since most trips involve multiple destinations.
- Transit vehicles enter and leave the airport via the Bayshore Freeway interchange with the exception of Greyhound and Hotel Courtesy Limousines.
- Transit vehicles, limousines and other "re-circulating" traffic changes enplaning/de-planing levels via the loop road.

This process produced estimates of vehicular traffic on each roadway element and intersection within the airport complex and at interchange points with the local and regional highway system.

Roadway Capacity Calculation

The establishment of vehicular volumes, coupled with the data collected on geometric characteristics of the roadway system permitted calculation of the traffic-handling capacity of each intersection. This capacity represents the maximum number of vehicles which can be accommodated by the particular intersection. However, this "maximum" number is indicative of operation under the worst conditions of congestion and delay. Standard practice is to develop a set of capacities related to a level of service measure which in turn indicates how well an intersection is performing under various traffic loads. For at-grade intersections, the level of service is derived from examining the proportion of "loaded cycles." This proportion is referred to as a load factor, and is calculated by forming the ratio of the total number of green traffic signal intervals on any given intersection approach that are fully utilized by traffic during the peak hour to the total number of green intervals for that approach during the same period. For example, if the traffic signal changed once every minute, there would be 60 green intervals in an hour; if 30 of them were loaded with autos, the load factor would be 50%. Levels of service are normally subdivided into six categories (A-F), ranging from virtually free-flow conditions to maximum congestion and operational breakdown. When

designing a new intersection or highway, level of service C is standard design criteria. Most urban intersections operate at level of service D. The six levels of service are defined as follows:

- Level of Service A - There are no loaded cycles and few even approach being loaded. No approach phase is fully utilized by traffic and no vehicle waits longer than one red indication. Typically, the approach appears quite open, turning movements are easily made, and nearly all drivers find freedom of operation, their only concern being the chance that the light will be red, or turn red, as they approach.
- Level of Service B - The maximum load factor is 10%. An occasional approach phase is fully utilized and some are approaching full use.

- Level of Service C - Loading is still intermittent, but more frequent, with

the load factor ranging from 10% to 30%. Occasionally, drivers may have to wait through more than one red signal indication, and queues may develop behind turning vehicles. Most drivers feel somewhat restricted, but not objectionably so.

- Level of Service D - The load factor ranges from 30% to 70%, indicating that the intersection frequently appears loaded during the peak hour. Delays to approaching vehicles may occur during short periods within the peak hour, but enough cycles with lower demand occur to permit periodic clearance of developing queues, thus preventing excessive back-up.
- Level of Service E - Maximum capacity occurs at this level. It represents the largest number of vehicles that any particular intersection can accommodate. A load factor range of 70% to 100% is realistic. At capacity, there may be queues of vehicles waiting upstream of the intersection and

delays may be great (up to several signal cycles).

- Level of Service F - This level represents jammed conditions. The intersection operates erratically under forced flow and maximum congestion exists. No load factor can be determined because full utilization is prevented by outside conditions.

Two other "side items" need to be examined in the airport environment. Having established the traffic volumes and intersection capacities it is then necessary to relate these volumes to needs for long and short term parking and curb space requirements for pick-up/drop-off along the enplaning and deplaning roadways. The process of defining long and short term parking needs requires two basic steps. First, parking generation factors are established relating to the number of parked vehicles per air passenger with similar ratios formed for employees and other subgroups. As in the case of the traffic analysis transferring air passengers are eliminated from consideration. The parking generation factor is applied to parking characteristics for a given week. The result is the total number of parkers for that week, both long term and short term.

The second step in the parking demand analysis is the conversion of these parkers to accumulated parked vehicles, the maximum number of which at any one point in time sets required parking capacity. The basic techniques for this conversion are derived from Research Report No. 44, ITTE, University of California, titled Vehicular Traffic Patterns in Relation to Passenger Volumes, by Koussios and Homburger.

Curb place requirements are a function of the number of vehicles stopping and the length of time they stay. Capacity is expressed in foot minutes of curb and demand is represented by the average foot minutes per vehicle. These two parameters reflect curb frontage space requirements for various Classifications of vehicles.

Simulation Application

On survey day, the airport accommodated a total air passenger volume of 40,800 persons[1/] (Exhibit C-4). Transfer air passengers, or those who did not require ground transportation to or from the airport, amounted to 12.2%

1/ Total on/off (enplaned/deplaned) air passengers for the survey date as supplied by the individual airlines to the Airports Commission.

EXHIBIT C-4

San Francisco International Airport

1974 SURVEY DAY AIR PASSENGERS

	Passengers	Percent of Total
Air Passengers		
Enplaned	18,100	44.4
Deplaned	17,700	43.4
Subtotal	35,800	87.8
Transfers	5,000	12.2
TOTAL SURVEY DAY AIR PASSENGERS	40,800	100.0%

of total usage or 5,000 persons. Of the estimated 35,800 air passengers requiring access to or from the airport, about 18,100 were enplaning passengers and 17,700 were deplaning users. The central terminal handled 60% of these air passengers while the south terminal accommodated the remaining 40%.

Non-air passengers on survey day totaled about 14,600 persons. Thus, the derived ratio of non-air passengers to total enplaning and deplaning patrons was 0.409 on January 10, 1975.

Approximately 30,000 persons were employed at San Francisco International Airport on the survey day. This estimate is based on a 1972 analysis of the "Economic Impact of San Francisco International Airport on San Francisco and Surrounding Communities." On any given day, however, the actual number of employees at the airport is about 12.5% lower than the above number due to vacations, sickness and flight schedule demands. For this reason, the employment figure used for the base year simulation was 26,300 persons. As illustrated in Exhibit C-5 , airline workers represent about 22,400 jobs or 85% of total airport employment. The

EXHIBIT C-5

San Francisco International Airport

1974 SURVEY DAY ESTIMATED EMPLOYMENT DISTRIBUTION BY CATEGORY

	Total	Percent of Total
Airline Employees		
Maintenance	11,000	41.8%
Flight Crews	4,900	18.6
Administrative/Customer Service	6,500	24.7
Subtotal	22,400	85.1%
Non-Airline Employees		
Retail	1,400	5.3%
Miscellaneous	2,500	9.6
Subtotal	3,900	14.9%
TOTAL SURVEY DAY EMPLOYMENT	26,300	100.0%

remaining number of the airport labor force is comprised of persons employed in retail and miscellaneous endeavors.

Total survey day population at the airport is comprised of the summation of air passengers, non-air passengers and airport employees. As indicated in Exhibit C-6 , nearly one-half of survey day population of 81,700 persons was represented by enplaning, deplaning and transfer air passengers while about two-thirds of remaining airport population consists of airport employees.

The airport population, however, is not an accurate measure of the number of daily person trips or vehicle trips made to or from the airport on a typical weekday. It is estimated that the enplaning and deplaning air passenger makes one person trip either to or from the airport while members of the other population subgroups each make two trips.

As demonstrated in Exhibit C-7 , about 117,600 person trips were attributed to the airport population on the survey day. Not surprisingly, non-air passengers and airport employees account for about 81,800 person trips or approximately 69.5% of all airport-related person trips.

EXHIBIT C-6

San Francisco International Airport

1974 SURVEY DAY AIRPORT POPULATION

	Total	Percent of Total
Air Passengers		
Enplaned	18,100	22.2%
Deplaned	17,700	21.7
Transfers	5,000	6.0
Subtotal	40,800	49.9%
Non-Air Passengers	14,600	17.9
Airport Employees		
Airline Employees	22,400	27.4%
Non-Airline Employees	3,900	4.8
Subtotal	26,300	32.2%
TOTAL SURVEY DAY POPULATION	81,700	100.0%

EXHIBIT C-7

San Francisco International Airport

1974 SURVEY DAY TOTAL PERSON TRIPS

Airport Population Group	1974 Survey Day	Percent of Total
Air Passengers		
Enplaned	18,100	15.4%
Deplaned	17,700	15.1
Non-Air Passengers	29,200	24.8
Airport Employees	52,600	44.7
TOTAL SURVEY DAY PERSON TRIPS	117,600	100.0%

Nearly six of 10 person trips made by enplaning and deplaning air passengers involved the use of automobiles and rental cars (Exhibit C-8). Nevertheless, about one-third of the persons in this population subgroup arrive or depart from the airport by regularly scheduled transit services or by specially provided shuttle bus services.

In contrast to the access modes used by air passengers, non-air passengers and airport employees almost exclusively depend upon the automobile for transportation (Exhibits C-9 and C-10). Of 81,800 person trips made by these two airport user subgroups, about 77,200 trips or 94.3% of total access and egress demands occur by private transportation.

In aggregate terms, more than eight of 10 members of the airport population rely on automobiles for transportation (Exhibit C-11). Regularly scheduled mass transit services and para-transit operations (taxis and shuttle buses) account for an additional 16.6% of person trips while rental cars serve the remaining 2% of daily person trips.

Total person trips are disaggregated by mode into vehicle trips by applying appropriate vehicle occupancy

EXHIBIT C-8

San Francisco International Airport

1974 SURVEY DAY MODE SPLIT DISTRIBUTION TOTAL AIR PASSENGERS PERSON TRIPS

Mode of Transportation	Air Passengers Enplaned	Deplaned	Totals	Percent Distribution
Auto	9,800	8,700	18,500	51.7%
Rental Auto	1,400	900	2,300	6.4
Bus	2,700	3,000	5,700	15.9
Taxi	1,300	1,800	3,100	8.7
Other	2,900	3,300	6,200	17.3
TOTALS	18,100	17,700	35,800	100.0%

EXHIBIT C-9

San Francisco International Airport

1974 SURVEY DAY MODE SPLIT DISTRIBUTION TOTAL NON-AIR PASSENGER PERSON TRIPS

Mode of Transportation	Non-Air Passengers	Percent Distribution
Auto	27,800	95.2%
Rental Auto	-	-
Bus	1,400	4.8
Taxi	-	-
Other	-	-
TOTALS	29,200	100.0%

EXHIBIT C-10

San Francisco International Airport

1974 SURVEY DAY MODE SPLIT DISTRIBUTION TOTAL EMPLOYEE PERSON TRIPS

Mode of Transportation	Employees	Percent Distribution
Auto	49,400	93.9%
Rental Auto	-	-
Bus	2,800	5.3
Taxi	-	-
Other	400	0.8
TOTALS	56,200	100.0%

EXHIBIT C-11

San Francisco International Airport

1974 SURVEY DAY MODE SPLIT DISTRIBUTION TOTAL PERSON TRIPS

Mode of Transportation	Air Passengers	Non-Air Passengers	Employees	Total	Percent Distribution
Auto	18,500	27,800	49,400	95,700	81.4%
Rental Auto	2,300	-	-	2,300	2.0
Bus	5,700	1,400	2,800	9,900	8.4
Taxi	3,100	-	-	3,100	2.6
Other	6,200	-	400	6,600	5.6
TOTALS	35,800	29,200	52,600	117,600	100.0%

factors (Exhibit C-12). Of the 84,500 daily vehicle trips oriented to San Francisco International Airport, about 86.7% or 73,300 trips, were made by private auto. The remaining 13.3% of total daily vehicle trips were distributed among rental auto, bus, taxi and other. Interestingly, while buses transport about 8.4% of all person trips to the facility, they comprise only 0.6% of total vehicles using the complex principally because of comparatively high numbers of passengers carried per bus.

In addition to vehicle trips produced by the airport population, truck and other commercial vehicle trips are also generated in the course of a typical weekday at the airport. Based upon traffic counts conducted at the airport on survey day, an estimated 1,900 such trips were produced by vehicles serving the complex.

The final step in the simulation process involved the distribution of the calculated travel demands to roadways within and adjacent to the airport property. After all volumes were assigned, accuracy and verification checks were made by comparing assigned volumes to actual survey day counts. On all roadway links, simulated flows were within 10% of actual (Exhibit C-13) indicating that the simulation process formed a reliable methodology for estimating future traffic volumes as a function of air travel volumes and other subgroups.

EXHIBIT C-12

San Francisco International Airport

1974 SURVEY DAY TOTAL VEHICLE TRIPS

Mode of Transportation	Terminal Simulation	Rest of SFIA	Total	Percent Distribution
Auto	38,500	34,800 1/	73,300	86.7%
Rental Auto	2,000	-	2,000	2.4
Bus	400 2/	100 3/	500	0.6
Taxi	3,800	-	3,800	4.5
Other	3,000 4/	1,900 5/	4,900	5.8
TOTALS	47,700	36,800	84,500	100.0%

1/ Employee vehicle trips plus vehicles to remote parking including Anza and Park-N-Fly lots.
2/ Greyhound and airporter buses.
3/ UAL bus service.
4/ Airport shuttle bus, Anza and Park-N-Fly shuttle buses, and hotel/motel courtesy buses.
5/ Truck activity.

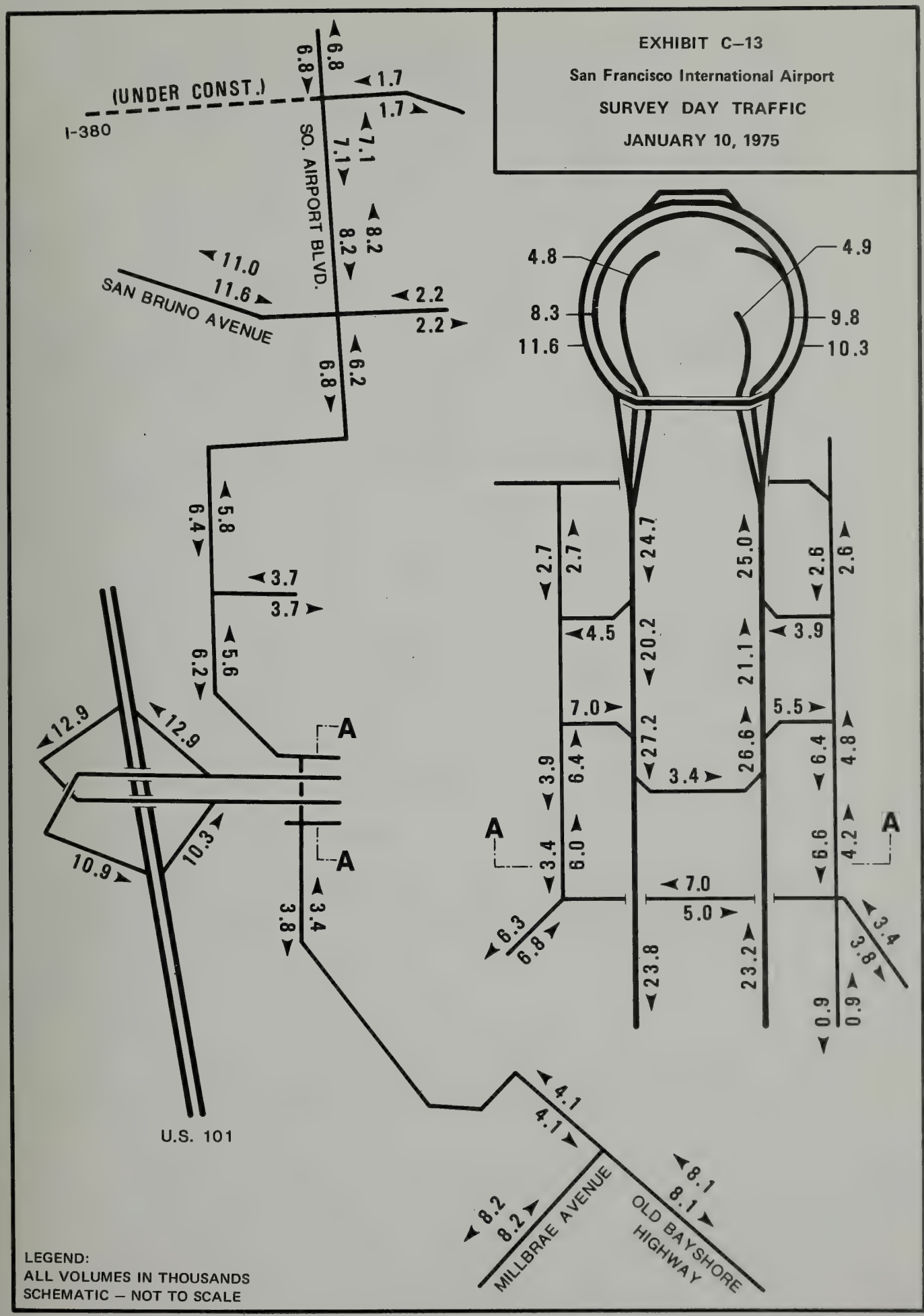


EXHIBIT C–13
San Francisco International Airport
SURVEY DAY TRAFFIC
JANUARY 10, 1975
(UNDER CONST.)
I-380
SO. AIRPORT BLVD.
SAN BRUNO AVENUE
U.S. 101
MILLBRAE AVENUE
OLD BAYSHORE HIGHWAY
A
LEGEND:
ALL VOLUMES IN THOUSANDS
SCHEMATIC – NOT TO SCALE

4. SIMULATION OF DESIGN DAY CONDITIONS - 1974

Simulation of person and vehicular movements in and around San Francisco International Airport on the survey day provided an accurate indicator of actual traffic conditions. The examination of airport access facilities, nevertheless, requires the analysis of travel demand which is likely to occur on the "design day." The design day is defined as that 24-hour period when the airport experiences the 37th highest daily usage throughout the course of a typical year.

For San Francisco International Airport, the month of August registers the highest volume of air passengers and the design day is an average day in that month. In 1974, August accounted for about 1,720,000 passengers or 10.6% of the annual number of passengers enplaning, deplaning or transferring at San Francisco International Airport. The average design day in August is then calculated by dividing the number of monthly air passengers in August by the number of days in that month.

There are approximately 55,500 air passengers using San Francisco International Airport on a typical day in August.

The design day air passenger usage is, therefore, about 36% greater than the corresponding 40,800 enplaning, deplaning and transfer air passengers recorded on the survey day.

Air passengers expected to use San Francisco International Airport on the design day are derived by expanding survey day results by a factor of 1.36 (Exhibit C-14). This computation merely converts survey day results to an average daily demand experienced during August.

The difference between the survey day and the design day non-air passenger population is assumed to vary only about two-thirds as much as the disparity between survey day air passengers and design day air passengers. It is estimated that design day non-air passengers total about 18,000 or about 23% more than the 14,600 non-air passengers recorded on survey day.

Unlike the other two components of airport population, the number of airport employees is assumed to remain unchanged at 26,300 jobs between survey day and design day.

Total design day population at San Francisco International Airport is comprised of the summation of air passengers,

EXHIBIT C-14

San Francisco International Airport

1974 DESIGN DAY AIR PASSENGERS

	1974 Design Day	1974 Survey Day
Air Passengers		
Enplaned	24,600	18,100
Deplaned	24,100	17,700
Subtotal	48,700	35,800
Transfers	6,800	5,000
TOTAL DESIGN DAY AIR PASSENGERS	55,500	40,800

EXHIBIT C-15

San Francisco Internaional Airport

1974 DESIGN DAY AIRPORT POPULATION

Airport Population Group	Totals	Percent of Total
Air Passengers		
Enplaned	24,600	24.6%
Deplaned	24,100	24.1
Transfers	6,800	6.8
Subtotal	55,500	18.0%
Non-Air Passengers	18,000	18.0%
Employees		
Airline	22,400	22.5%
Non-Airline	3,900	3.9
Subtotal	26,300	26.4%
TOTALS	99,800	100.0%

EXHIBIT C-16

San Francisco International Airport

1974 DESIGN DAY TOTAL PERSON TRIPS

Airport Population Group	1974 Design Day	1974 Survey Day	Ratio (Design Day/Survey Day)
Air Passengers			
Enplaned	24,600	18,100	1.36
Deplaned	24,100	17,700	1.36
Non-Air Passengers	36,000	29,200	1.23
Employees	52,600	52,600	-
TOTAL DESIGN DAY PERSON TRIPS	137,300	117,600	1.17

non-air passengers and airport employees. As indicated in Exhibit C-15, more than one-half of the design day population of 99,800 persons were represented by enplaning, deplaning and transfer air passengers while about 60% of the remaining population consists of airport employees.

The total airport population generates about 137,300 person trips on the design day (Exhibit C-16). Overall, person trips on the design day exceed the survey day by about 17% or 19,700 trips. Approximately two-thirds of the design day trips are attributed to non-air passengers and airport employees.

Similar to the survey day, nearly six of 10 person trips made by enplaning and deplaning air passengers involve the use of automobiles or rental cars (Exhibit C-17). The remaining 40% of the person trips made by this population subgroup utilize regularly scheduled bus service, taxis and shuttle bus operations.

The modal split distributions for non-air passengers and airport employees on the design day remain unchanged from results recorded on the survey day.

EXHIBIT C-17

San Francisco International Airport

1974 Design Day Mode Split Distribution

Total Air Passenger Person Trips

Mode of Transportation	Air Passengers Enplaned	Deplaned	Totals	Percent Distribution
Auto	13,500	11,900	25,400	52.2
Rental Auto	1,900	1,200	3,100	6.4
Bus	3,700	4,100	7,800	16.0
Taxi	1,800	2,500	4,300	8.8
Other	3,700	4,400	8,100	16.6
TOTALS	24,600	24,100	48,700	100.0

In aggregate terms, nearly eight of 10 members of the airport population rely on automobiles for transportation to and from the airport (Exhibit C-18). Regularly scheduled transit buses, which account for 9.0% of person trips, carry the second largest volume of airport users. The residual person trips are accounted for by rental cars, taxis and shuttle bus services.

Total person trips disaggregated by mode were converted into vehicle trips by applying appropriate vehicle occupancy factors (Exhibit C-19). As illustrated, about 88.4% of the 98,800 design day trips oriented to San Francisco International Airport were made by private automobile. The remaining number of 11,500 daily vehicle trips to and from the terminal and the rest of the airport complex were made by rental cars, buses, taxis and shuttle service vehicles.

The allocation of these travel volumes to the roadway system within the airport is illustrated in Exhibit C-20. This detailed breakdown for design day total and peak hour volumes forms the basis for the comparison with roadway capacities presented in Section 6 - Impact Assessment. A companion chart (Exhibit C-21) shows the

EXHIBIT C-18

San Francisco International Airport

1974 Design Day Mode Split Distribution

Total Person Trips

Mode of Transportation	Air Passengers	Employees	Non-Air Passengers	Totals	Percent Distribution
Auto	25,400	49,400	34,300	109,100	79.5
Rental Auto	3,100	-	-	3,100	2.2
Bus	7,800	2,800	1.700	12,300	9.0
Taxi	4,300	-	-	4,300	3.1
Other	8,100	400	-	8,500	6.2
TOTALS	48,700	52,600	36,000	137,300	100.0

EXHIBIT C-19

San Francisco International Airport

1974 Design Day Total Vehicle Trips

Mode of Transportation	Terminal Simulation	Rest of SFIA	Totals	Percent Distribution
Auto	52,500	34,800 [1]	87,300	88.4
Rental Auto	2,000	-	2,000	2.0
Bus	400 [2]	100 [3]	500	0.5
Taxi	4,100	-	4,100	4.1
Other	3,000 [4]	1,900 [5]	4,900	5.0
TOTALS	62,000	36,800	98,800	100.0

1/ Employee vehicle trips plus vehicles to remote parking including Anza and Park-N-Fly lots.
2/ Greyhound and Airporter buses.
3/ UAL bus service
4/ Airport shuttle bus, Anza and Park-N-Fly shuttle buses, and hotel/motel courtesy buses.
5/ Truck activity.

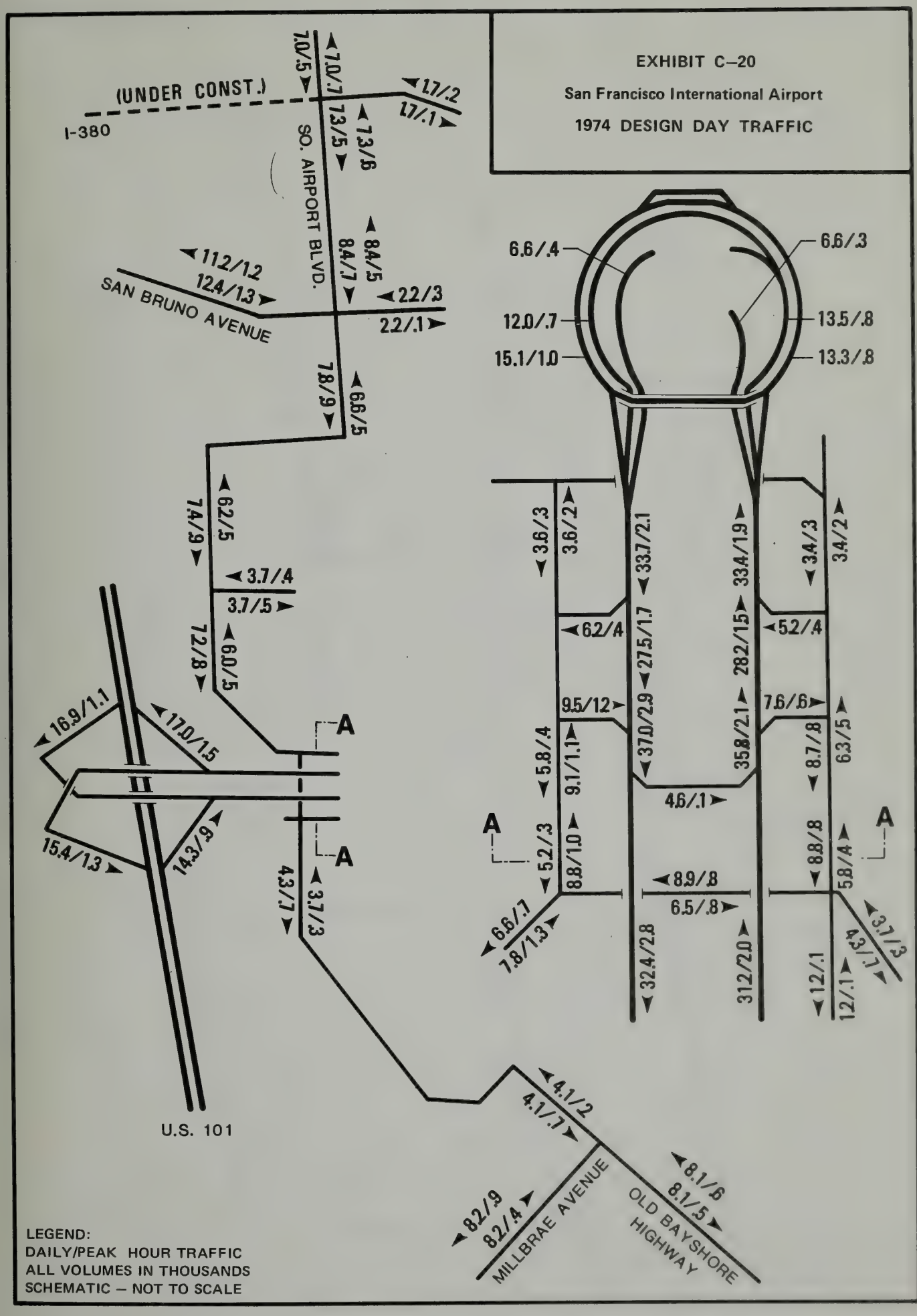


EXHIBIT C–20
San Francisco International Airport
1974 DESIGN DAY TRAFFIC
(UNDER CONST.)
I-380
SO. AIRPORT BLVD.
SAN BRUNO AVENUE
U.S. 101
MILLBRAE AVENUE
OLD BAYSHORE HIGHWAY
A
LEGEND:
DAILY/PEAK HOUR TRAFFIC
ALL VOLUMES IN THOUSANDS
SCHEMATIC – NOT TO SCALE

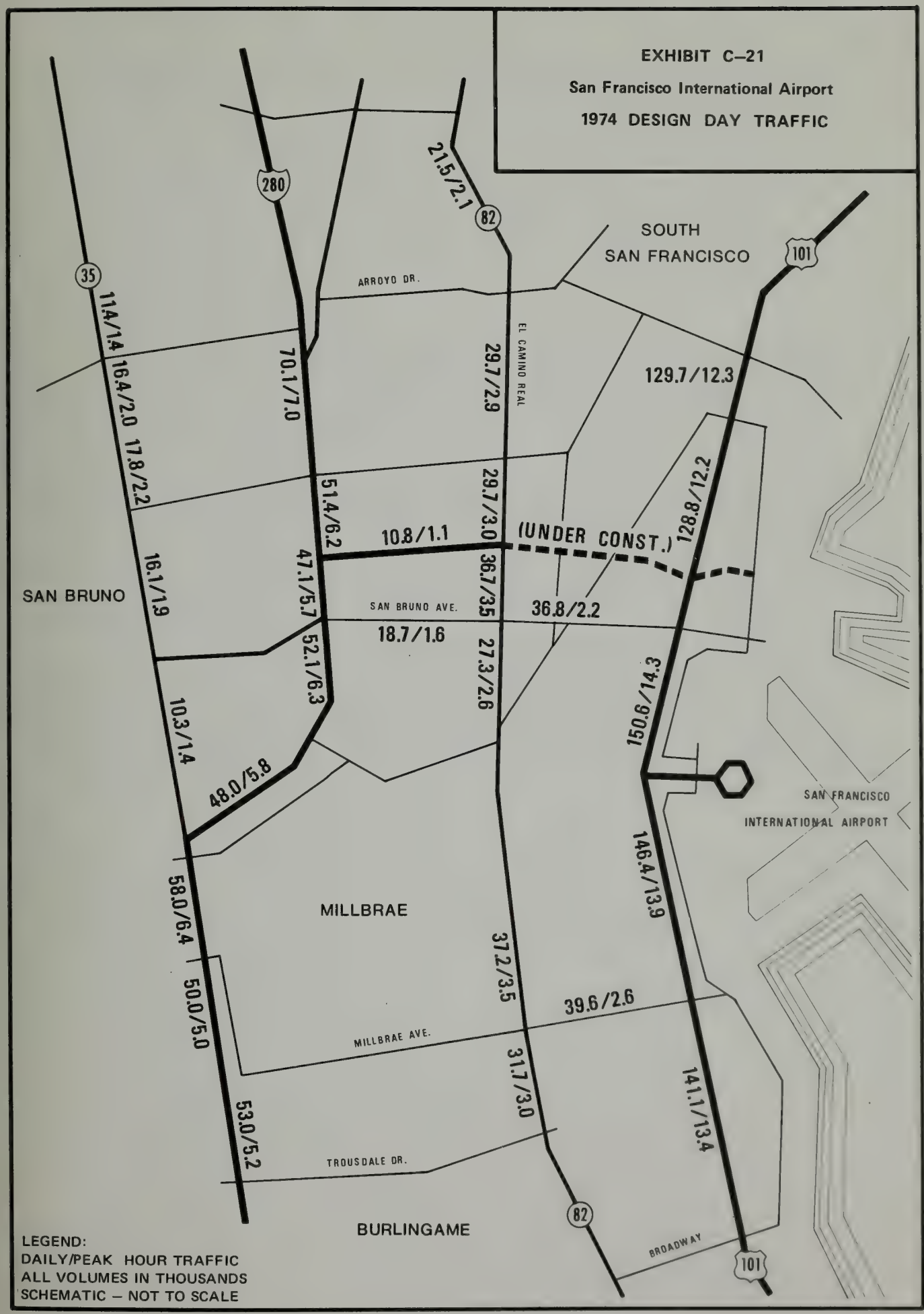


EXHIBIT C–21
San Francisco International Airport
1974 DESIGN DAY TRAFFIC
280
82
35
101
SOUTH
SAN FRANCISCO
ARROYO DR.
EL CAMINO REAL
SAN BRUNO
SAN BRUNO AVE.
MILLBRAE
MILLBRAE AVE.
TROUSDALE DR.
BURLINGAME
BROADWAY
SAN FRANCISCO
INTERNATIONAL AIRPORT
(UNDER CONST.)
21.5/2.1
114/1.4
16.4/2.0
17.8/2.2
16.1/1.9
10.3/1.4
48.0/5.8
58.0/6.4
50.0/5.0
53.0/5.2
70.1/7.0
51.4/6.2
47.1/5.7
52.1/6.3
29.7/2.9
29.7/3.0
36.7/3.5
18.7/1.6
27.3/2.6
37.2/3.5
31.7/3.0
10.8/1.1
129.7/12.3
128.8/12.2
36.8/2.2
150.6/14.3
146.4/13.9
39.6/2.6
141.1/13.4
LEGEND:
DAILY/PEAK HOUR TRAFFIC
ALL VOLUMES IN THOUSANDS
SCHEMATIC – NOT TO SCALE

allocation of these volumes to the regional highway network. This exhibit combines design day air travel with average daily traffic on the regional roadway system which is not airport-related to produce total volumes and peak travel.

Average Annual Traffic

The ground access impact assessment utilizes design day volumes to assure a comparison of capacities with appropriate traffic volumes. However, the analysis of air quality resulting from traffic flows requires that these volumes be converted to average annual daily traffic data. Exhibits C-22 and C-23 are companion charts to the design day maps illustrating this conversion. Comparison of these charts indicates that the average annual daily traffic (AADT) volumes are approximately 20% lower than design day traffic.

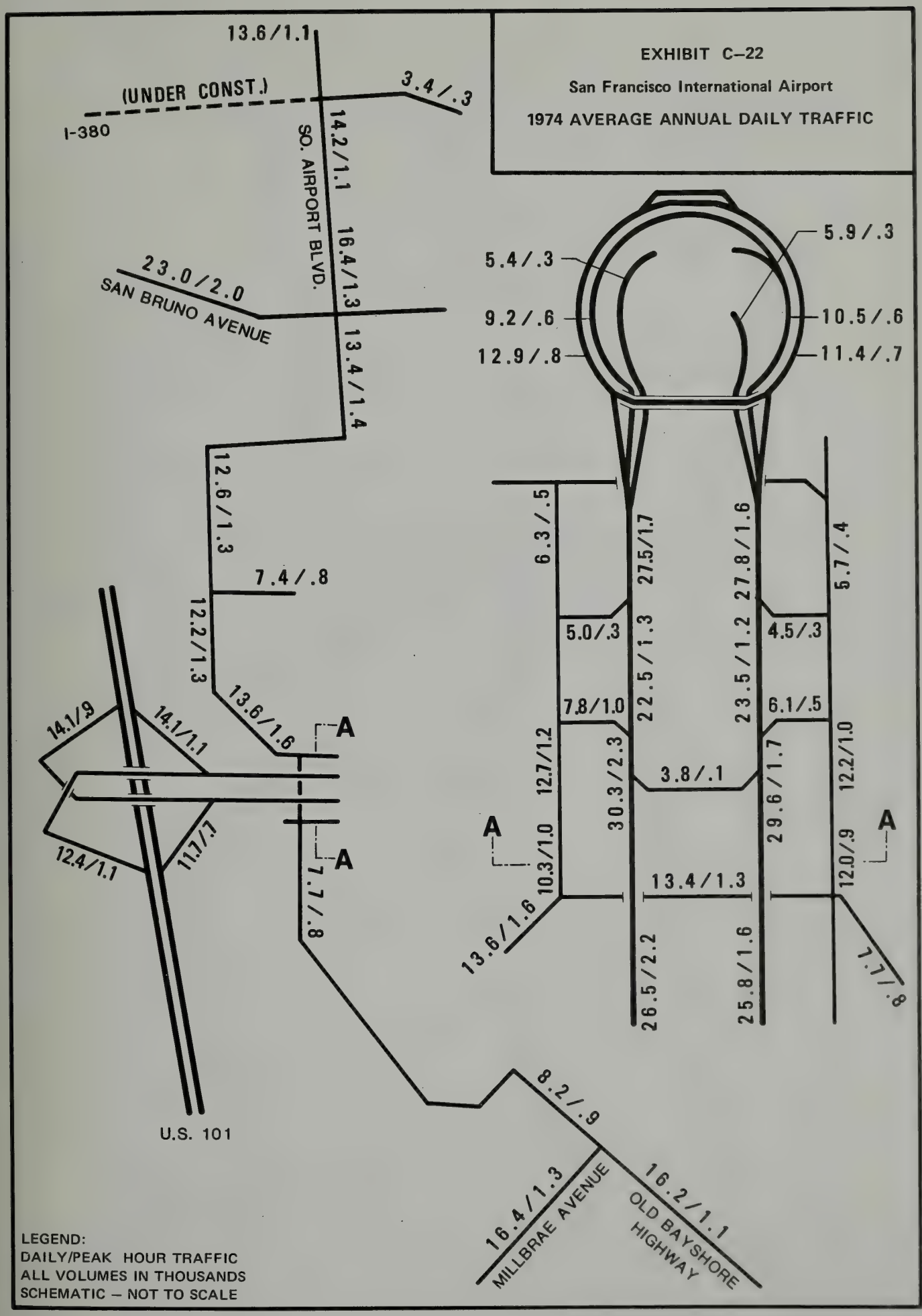


EXHIBIT C–22
San Francisco International Airport
1974 AVERAGE ANNUAL DAILY TRAFFIC
13.6/1.1
(UNDER CONST.)
3.4/.3
I-380
SO. AIRPORT BLVD.
14.2/1.1
16.4/1.3
23.0/2.0
SAN BRUNO AVENUE
13.4/1.4
12.6/1.3
7.4/.8
12.2/1.3
13.6/1.6
14.1/.9
14.1/1.1
12.4/1.1
11.7/.7
A
A
7.7/.8
U.S. 101
8.2/.9
16.4/1.3
MILLBRAE AVENUE
16.2/1.1
OLD BAYSHORE HIGHWAY
5.4/.3
9.2/.6
12.9/.8
5.9/.3
10.5/.6
11.4/.7
6.3/.5
27.5/1.7
27.8/1.6
5.7/.4
5.0/.3
4.5/.3
22.5/1.3
23.5/1.2
7.8/1.0
6.1/.5
12.7/1.2
30.3/2.3
3.8/.1
29.6/1.7
12.2/1.0
A
A
10.3/1.0
13.4/1.3
12.0/.9
13.6/1.6
26.5/2.2
25.8/1.6
1.1/.8
LEGEND:
DAILY/PEAK HOUR TRAFFIC
ALL VOLUMES IN THOUSANDS
SCHEMATIC – NOT TO SCALE

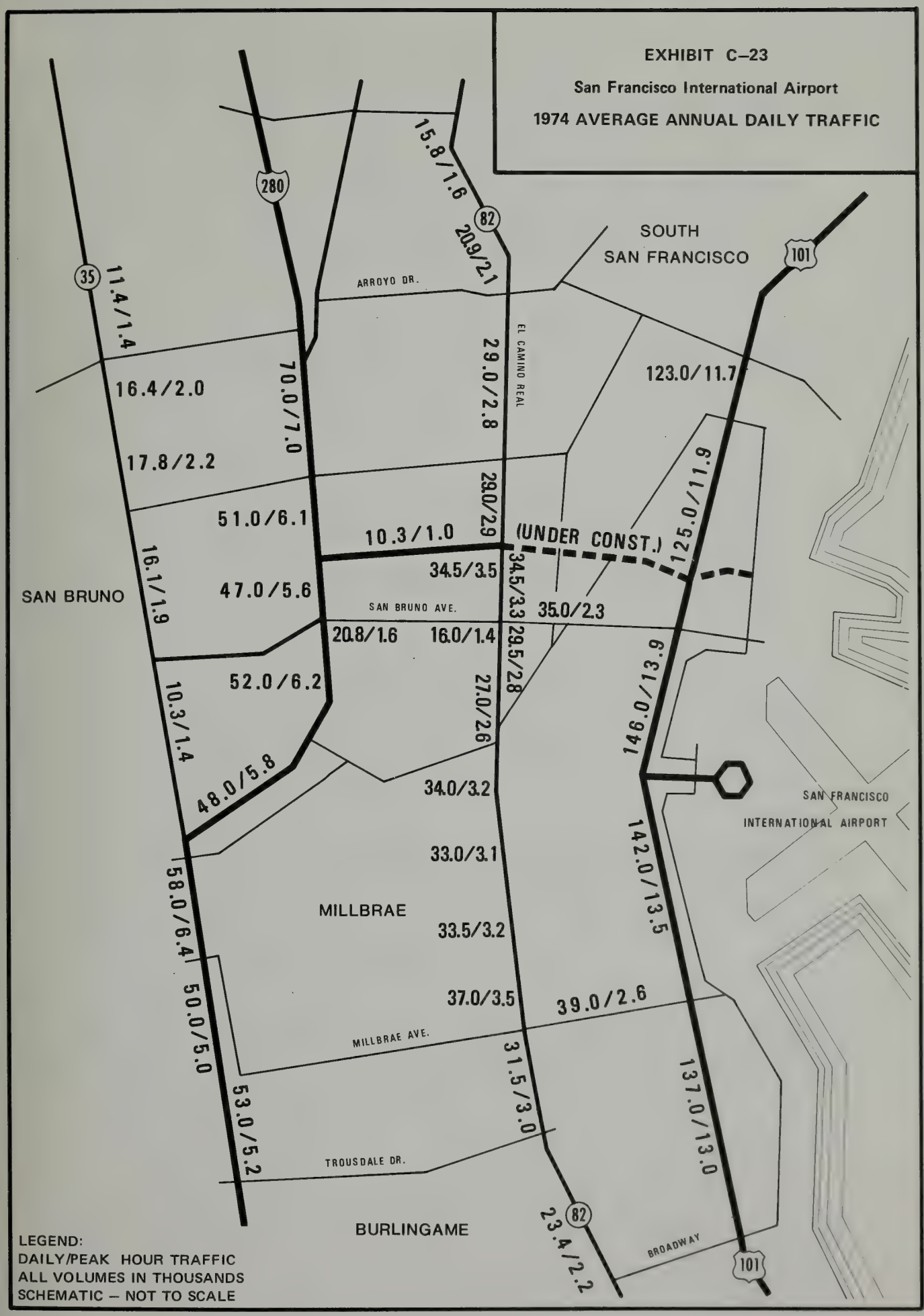


EXHIBIT C–23
San Francisco International Airport
1974 AVERAGE ANNUAL DAILY TRAFFIC
280
82
35
101
SOUTH SAN FRANCISCO
ARROYO DR.
EL CAMINO REAL
SAN BRUNO
SAN BRUNO AVE.
MILLBRAE
MILLBRAE AVE.
TROUSDALE DR.
BURLINGAME
BROADWAY
SAN FRANCISCO INTERNATIONAL AIRPORT
(UNDER CONST.)
15.8/1.6
20.9/2.1
11.4/1.4
16.4/2.0
17.8/2.2
70.0/7.0
29.0/2.8
123.0/11.7
51.0/6.1
29.0/2.9
10.3/1.0
125.0/11.9
16.1/1.9
47.0/5.6
34.5/3.5
34.5/3.3
35.0/2.3
20.8/1.6
16.0/1.4
29.5/2.8
52.0/6.2
27.0/2.6
146.0/13.9
10.3/1.4
48.0/5.8
34.0/3.2
33.0/3.1
142.0/13.5
58.0/6.4
33.5/3.2
37.0/3.5
39.0/2.6
50.0/5.0
31.5/3.0
137.0/13.0
53.0/5.2
23.4/2.2
LEGEND:
DAILY/PEAK HOUR TRAFFIC
ALL VOLUMES IN THOUSANDS
SCHEMATIC – NOT TO SCALE

5. SIMULATION OF DESIGN DAY TRAFFIC - 1982

Air travel projections indicate that by the year 1982, 24.4 million annual air passengers will use San Francisco International Airport. The simulation process employed to convert this to design day traffic is the same as that employed for 1974. However, several changes are anticipated in the physical facilities in and around the airport. These include:

- Completion of the I-380 Extension connecting its present terminus at El Camino Real with South Airport Boulevard and the north access road. Further, a direct connection from I-380 paralleling the Bayshore Freeway will provide access via the main east-west airport terminal road.

- The terminal garage will be completed raising the number of available parking spaces from the existing 3,100 to 7,300.

- Completion of the north air passenger terminal which will handle approximately one-third of

the airport's total air passenger activity.

- Improved level of bus service from population centers in San Mateo County as specified in the 1974 San Mateo County Local Bus Transit Study. These changes include an express route (No. 130) and a local route (No. 24) providing 15-minute and 30-minute service, respectively.

The extension of I-380 affects travel patterns to and from the airport and to some degree within the airport property. The principal beneficiary from this new construction is San Bruno Avenue which loses traffic to I-380. The effect of the improved bus service is to cause approximately 4% of the employee person trips (3,000 out of 72,400) to shift to public transit.

The effect of air travel growth to 24.4 million on airport population subgroups is shown on Exhibit C- 24. Each population category increases approximately by a factor of 1.5 with design day air passengers increasing to

EXHIBIT C-24

San Francisco International Airport

1982 Design Day Estimated Airport Population

Airport Population Group	1982 Design Day	1974 Design Day	Ratio 1982/1974
Air Passengers			
Enplaned	37,000	24,600	
Deplaned	36,200	24,100	
Transfers	10,200	6,800	
Subtotal	83,400	55,500	1.5
Non-Air Passengers	27,000	18,000	1.5
Airline Employees			
Maintenance	13,600	11,000	
Flight Crews	7,200	4,900	
Administrative/ Customer Service	9,700	6,500	
Subtotal	30,500	22,400	1.4
Non-Airline Employees			
Retail	2,000	1.400	
Miscellaneous	3,700	2,500	
Subtotal	5,700	3,900	1.5
Subtotal Employees	36,200	26,300	1.5
TOTAL	146,600	99,800	1.5

83,400, non-air passengers and visitors to 27,000 and employees to 36,200, bringing the total population to 146,600.

The conversion of population subgroups to person trips results in a design day of 207,200 total person trips. The results of this conversion and the effects of improved bus service are illustrated in Exhibit C-25 which indicates that 79.2% of the total person trips will arrive by auto (private or rental).

The next step in the process converts these total person trips to vehicles to be assigned to the internal and regional roadway networks. In converting from person trips to vehicular trips, no change was made in vehicle occupancy rates with the exception that on some transit vehicles, load factors were increased in recognition of the fact that excess capacity exists today. The results of this conversion are indicated in Exhibit C-26 which totals 146,600 vehicle trips, up 48% from 1974.

As in the 1974 simulation process, 1982 design day and average annual daily traffic were assigned to the airport roadway system and the regional highway network. The results

EXHIBIT C-25

San Francisco International Airport

1982 DESIGN DAY MODE SPLIT DISTRIBUTION

TOTAL PERSON TRIPS

Mode of Transportation	Air Passengers	Employees	Non-Air Passengers	Totals	Percent Distribution
Auto	38,000	62,900	58,600	159,500	77.0
Rental Auto	4,600	-	-	4,600	2.2
Bus	11,800	8,800	3,000	23,600	11.4
Taxi	6,400	-	-	6,400	3.0
Other	12,400	700	-	13,100	6.4
TOTALS	73,200	72,400	61,600	207,200	100.0

EXHIBIT C-26

San Francisco International Airport

1982 DESIGN DAY TOTAL VEHICLE TRIPS

Mode of Transportation	Terminal Simulation	Rest of SFIA	Totals	Percent Distribution
Auto	82,100	47,800 1/	129,900	88.6
Rental Auto	3,300	-	3,300	2.2
Bus	500 2/	100 3/	600	0.4
Taxi	6,600	-	6,600	4.5
Other	3,400 4/	2,800 5/	6,200	4.3
TOTALS	95,900	50,700	146,600	100.0

1/ Employee vehicle trips plus vehicles to remote parking including Anza and Park-N-Fly lots.
2/ Greyhound and Airporter buses.
3/ UAL bus service.
4/ Airport shuttle bus, Anza and Park-N-Fly shuttle buses, and hotel/motel courtesy buses.
5/ Truck activity.

of this minimum path assignment are indicated in Exhibits C-27, C-28, C-29 and C-30. As in 1974, design day traffic averages approximately 20% higher than average annual daily traffic volumes. The increase in traffic for the design day is primarily a function of air traveler volumes since employee travel remains relatively constant.

6. SIMULATION OF DESIGN DAY TRAFFIC - 1990

Air travel projections indicate that by 1990 there will be a demand to serve 31 million annual air passengers. The techniques for converting this number to person trips and vehicles are the same as prior simulations. However, one basic difference exists in the 1990 analysis - - vehicular travel is estimated and assigned first under the assumption that rapid transit will not be extended to the airport and, secondly, that rapid transit will extend from Daly City through the airport.

At the 31 million air passenger level, 1990 design day air passengers convert to a total of 106,000 - - about a 30% increase over 1982 design day (83,400). This growth and change in other elements of the airport population are evident from Exhibit C-31. The corresponding change in

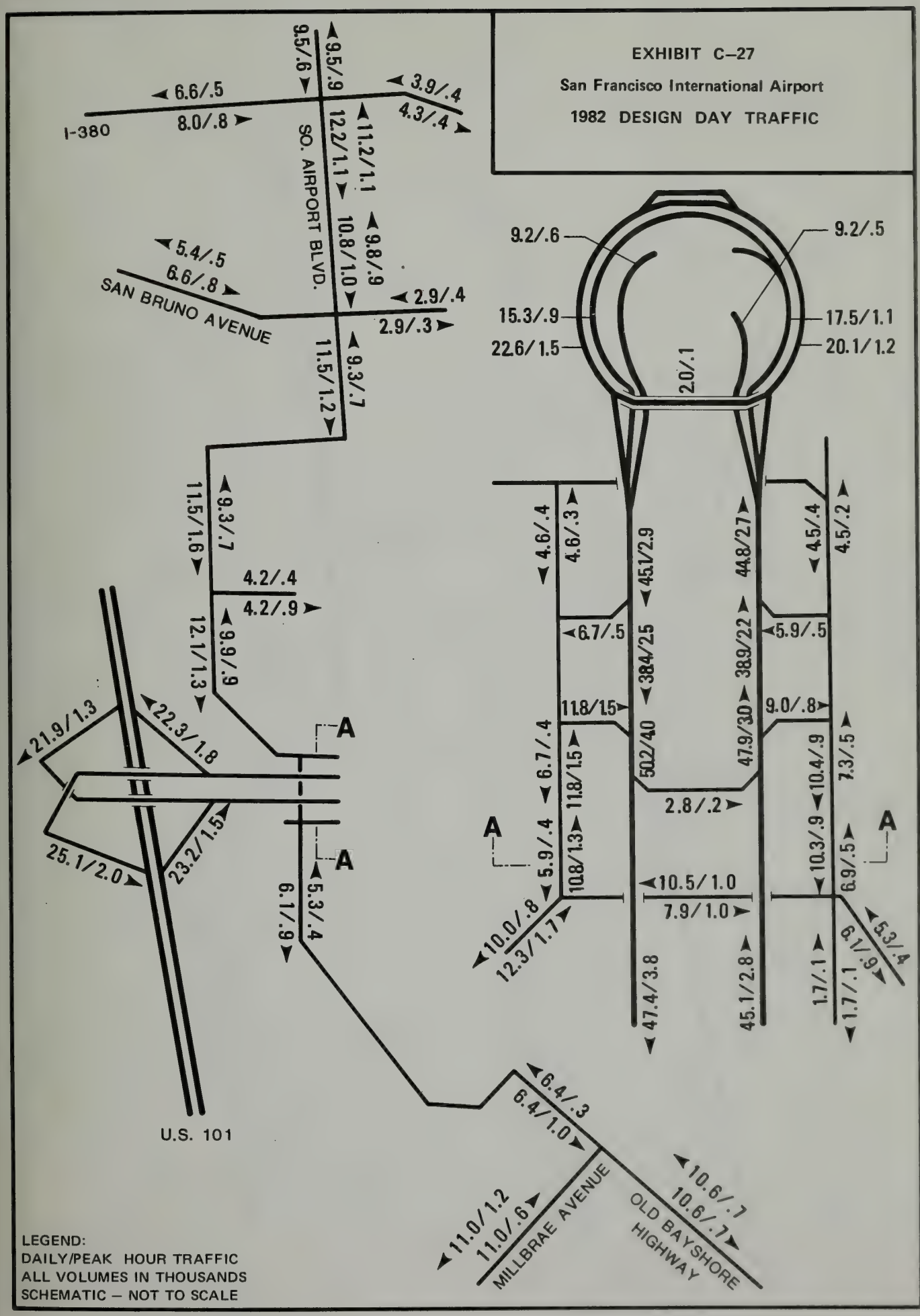


EXHIBIT C–27
San Francisco International Airport
1982 DESIGN DAY TRAFFIC
I-380
SO. AIRPORT BLVD.
SAN BRUNO AVENUE
U.S. 101
MILLBRAE AVENUE
OLD BAYSHORE HIGHWAY
A
LEGEND:
DAILY/PEAK HOUR TRAFFIC
ALL VOLUMES IN THOUSANDS
SCHEMATIC – NOT TO SCALE

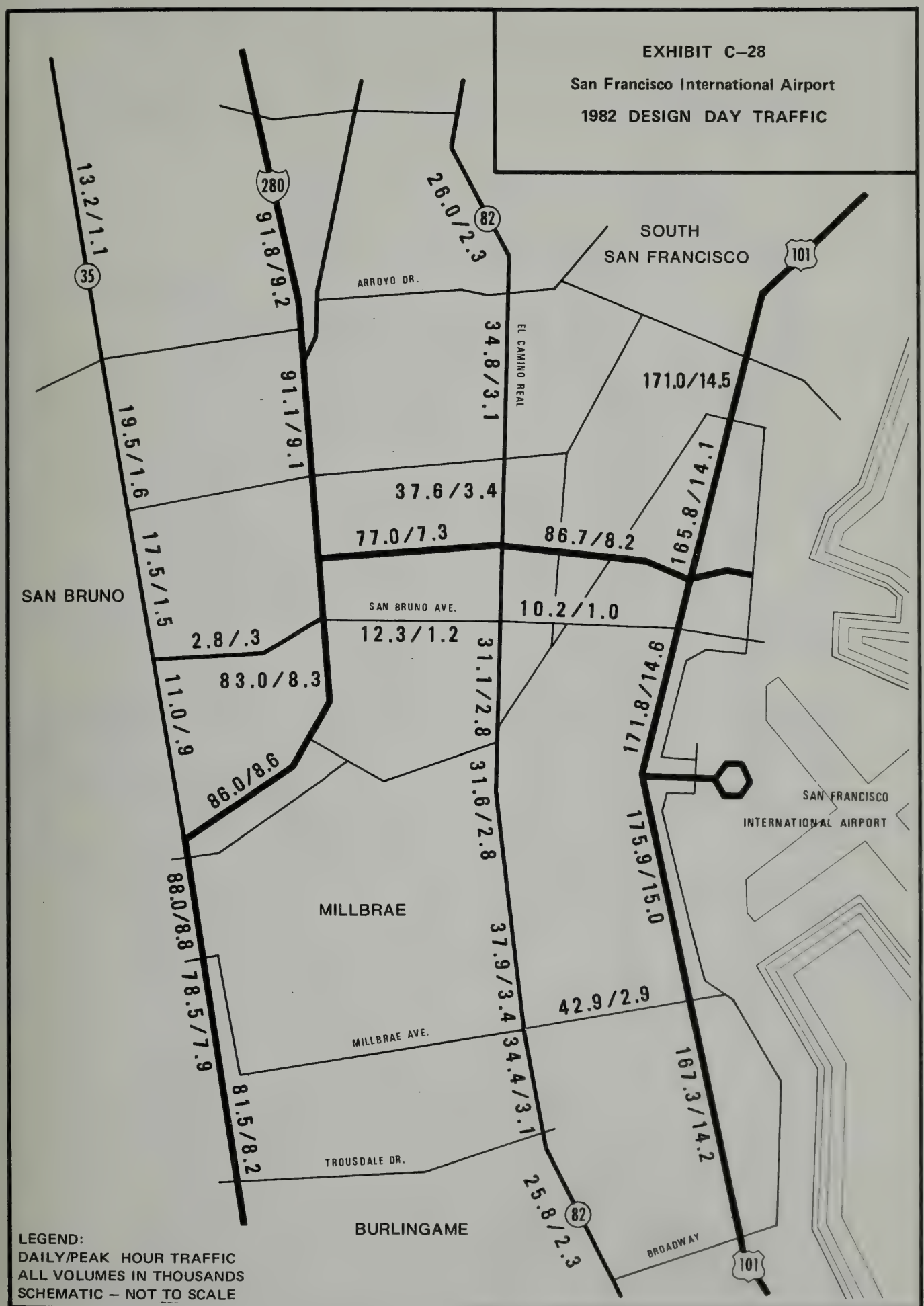


EXHIBIT C–28
San Francisco International Airport
1982 DESIGN DAY TRAFFIC
13.2/1.1
35
280
91.8/9.2
26.0/2.3
82
ARROYO DR.
SOUTH
SAN FRANCISCO
101
EL CAMINO REAL
34.8/3.1
91.1/9.1
171.0/14.5
19.5/1.6
37.6/3.4
77.0/7.3
86.7/8.2
165.8/14.1
17.5/1.5
SAN BRUNO
SAN BRUNO AVE.
10.2/1.0
2.8/.3
12.3/1.2
31.1/2.8
83.0/8.3
11.0/.9
171.8/14.6
86.0/8.6
31.6/2.8
SAN FRANCISCO
INTERNATIONAL AIRPORT
175.9/15.0
88.0/8.8
MILLBRAE
78.5/7.9
37.9/3.4
42.9/2.9
MILLBRAE AVE.
34.4/3.1
167.3/14.2
81.5/8.2
TROUSDALE DR.
25.8/2.3
82
BURLINGAME
BROADWAY
101
LEGEND:
DAILY/PEAK HOUR TRAFFIC
ALL VOLUMES IN THOUSANDS
SCHEMATIC – NOT TO SCALE

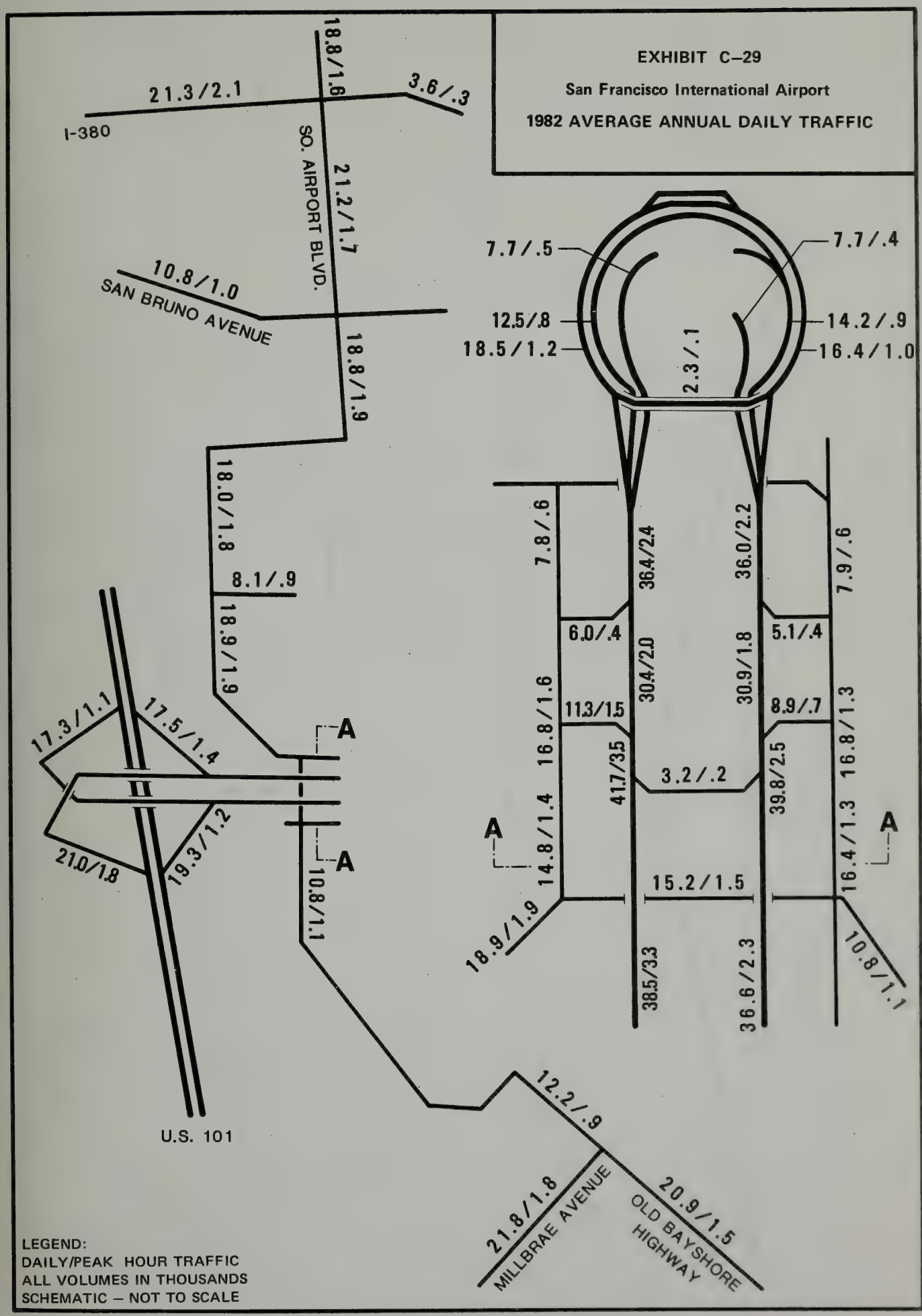


EXHIBIT C–29
San Francisco International Airport
1982 AVERAGE ANNUAL DAILY TRAFFIC
I-380
21.3/2.1
18.8/1.6
3.6/.3
SO. AIRPORT BLVD.
21.2/1.7
SAN BRUNO AVENUE
10.8/1.0
18.8/1.9
18.0/1.8
1.1/0.1
8.1/.9
18.8/1.9
7.7/.5
7.7/.4
12.5/.8
14.2/.9
18.5/1.2
16.4/1.0
2.3/.1
7.8/.6
36.4/2.4
36.0/2.2
7.9/.6
6.0/.4
5.1/.4
30.4/2.0
30.9/1.8
11.3/1.5
8.9/.7
16.8/1.6
16.8/1.3
41.7/3.5
39.8/2.5
3.2/.2
14.8/1.4
16.4/1.3
15.2/1.5
18.9/1.9
38.5/3.3
36.6/2.3
10.8/1.1
A
A
A
A
17.3/1.1
17.5/1.4
21.0/1.8
19.3/1.2
10.8/1.1
U.S. 101
12.2/.9
21.8/1.8
MILLBRAE AVENUE
20.9/1.5
OLD BAYSHORE HIGHWAY
LEGEND:
DAILY/PEAK HOUR TRAFFIC
ALL VOLUMES IN THOUSANDS
SCHEMATIC – NOT TO SCALE

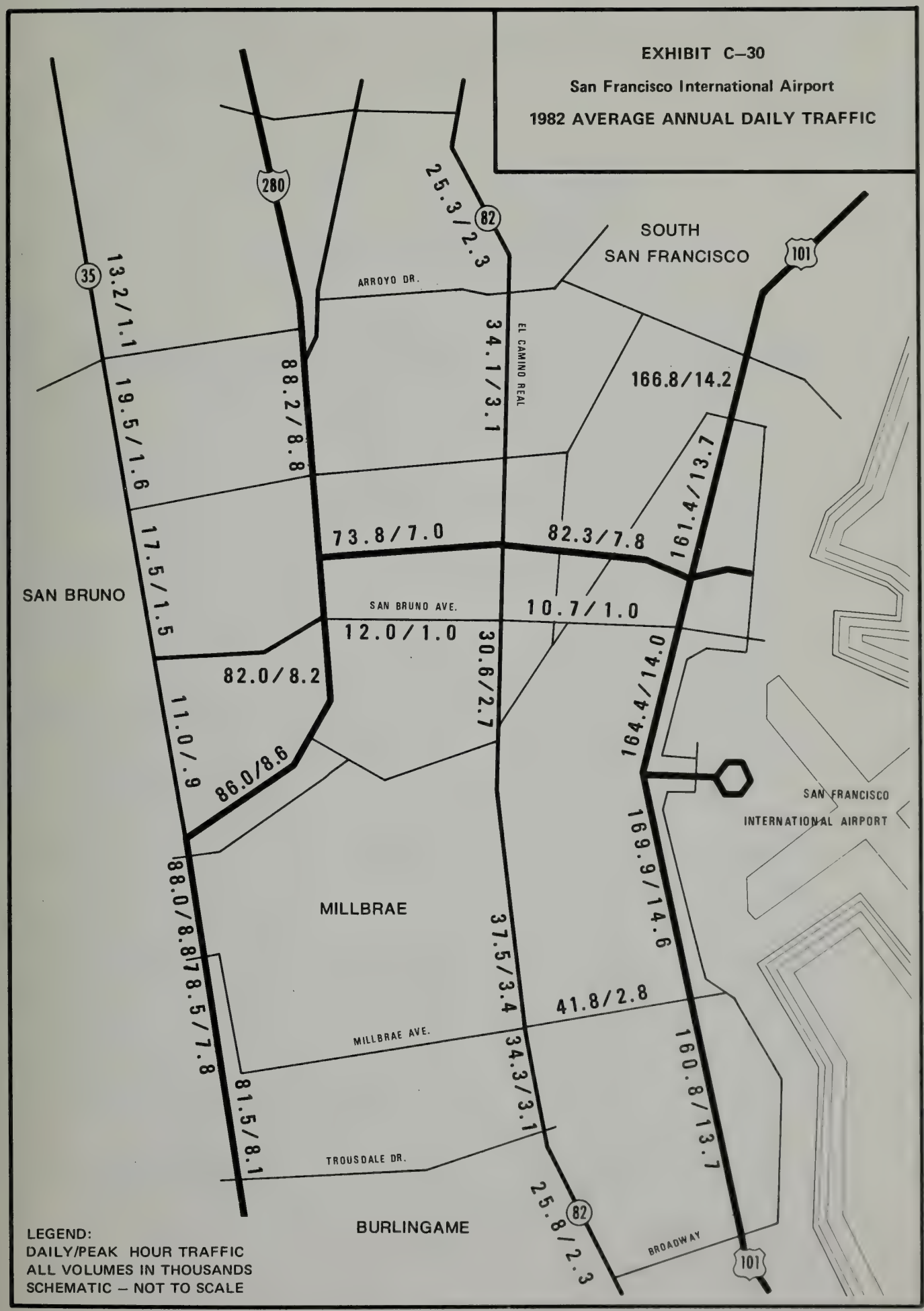


EXHIBIT C–30
San Francisco International Airport
1982 AVERAGE ANNUAL DAILY TRAFFIC
280
82
101
35
SOUTH
SAN FRANCISCO
ARROYO DR.
EL CAMINO REAL
SAN BRUNO
SAN BRUNO AVE.
MILLBRAE
MILLBRAE AVE.
TROUSDALE DR.
BURLINGAME
BROADWAY
SAN FRANCISCO
INTERNATIONAL AIRPORT
13.2/1.1
19.5/1.6
17.5/1.5
11.0/.9
86.0/8.6
88.0/8.8
78.5/7.8
81.5/8.1
88.2/8.8
82.0/8.2
25.3/2.3
34.1/3.1
73.8/7.0
12.0/1.0
30.6/2.7
37.5/3.4
34.3/3.1
25.8/2.3
166.8/14.2
161.4/13.7
82.3/7.8
10.7/1.0
164.4/14.0
169.9/14.6
41.8/2.8
160.8/13.7
LEGEND:
DAILY/PEAK HOUR TRAFFIC
ALL VOLUMES IN THOUSANDS
SCHEMATIC – NOT TO SCALE

EXHIBIT C-31

San Francisco International Airport

1990 DESIGN DAY AIRPORT POPULATION

Airport Population Group	1990 Design Day	1982 Design Day	Ratio (1990/1982)
Air Passengers			
Enplaned	47,000	37,000	
Deplaned	46,000	36,200	
Transfers	13,000	10,200	
Subtotal	106,000	83,400	1.3
Non-Air Passengers	34,300	27,000	1.3
Airline Employees			
Maintenance	15,400	13,600	
Flight Crews	9,200	7,200	
Administrative/ Customer Service	12,300	9,700	
Subtotal	36,900	30,500	1.2
Non-Airline Employees			
Retail	2,600	2,000	
Miscellaneous	4,800	3,700	
Subtotal	7,400	5,700	1.3
Subtotal employees	44,300	36,200	1.2
TOTAL DESIGN DAY AIRPORT POPULATION	186,400	146,600	1.3

design day employment represents about a 20% increase up from 36,200 to 44,300. Employment basically grows at the same rate as air passengers with the exception of maintenance employees who are estimated to have a growth rate at approximately one-half the air passenger rate. Under 1990 conditions, therefore, total airport population will approximate 186,400 persons. This population forms the pool of persons to be converted to person trips and vehicles under the "with and without rapid transit" options.

The conversion of this population to total person trips is represented in Exhibit C-32 and indicates design day travel of 274,300 person trips. This basic exhibit is, of course, a representation of modal split without rapid transit but forms the base for estimating diversion of travel as rapid transit is introduced. This exhibit is common to both analyses as a starting point.

1990 Design Day Vehicle
Travel Without Rapid Transit

This simulation option essentially carries forward the highway and public transit changes enumerated for the 1982 simulation. The mode split estimates for 1982 are essentially carried forward under this set of conditions

EXHIBIT C-32

San Francisco International Airport

1990 DESIGN DAY MODE SPLIT DISTRIBUTION
TOTAL PERSON TRIPS WITHOUT RAPID TRANSIT

Mode of Transportation	Air Passengers	Employees	Non-Air Passengers	Totals	Percent Distribution
uto	48,200	73,300	88,300	209,800	76.5
ental Auto	5,900	-	-	5,900	2.2
us	14,900	14,200	4,400	33,500	12.2
axi	8,100	-	-	8,100	3.0
ther	15,900	1,100	-	17,000	6.1
TALS	93,000	88,600	92,700	274,300	100.0

inasmuch as no basic changes are made in public transit or highway supply. On a person trip basis, the auto mode accounts for 76.5% in 1990 compared with an almost comparable 77.0% for 1982. Conversion to vehicular trips was made at 1982 occupancy rates. Throughout the analysis, no change was made in occupancy rates even though continuing fuel shortage and pricing problems may speak for raising occupancies. However, to insure an assessment of maximum impact, any factors which would tend to lessen vehicular travel (and were somewhat speculative) were not incorporated in the analysis. This conversion to vehicular trips in Exhibit C-33 shows a total of 204,700 vehicles. These represent total vehicles in and out of the airport area over the 24-hour design day.

As in the other simulations, the vehicular trips generated for the 1990 conditions without rapid transit were distributed over the internal and external roadway systems. Further, calculations were made to convert design day traffic to average annual daily traffic volumes. The results of this distribution are indicated in Exhibits C-34, C-35, C-36 and C-37.

EXHIBIT C-33

San Francisco International Airport

1990 DESIGN DAY TOTAL VEHICLE TRIPS WITHOUT RAPID TRANSIT

Mode of Transportation	Terminal Simulation	Rest of SFIA	Totals	Percent Distribution
Auto	119,900	60,100 1/	180,000	87.9
Rental Auto	4,600	-	4,600	2.2
Bus	600 2/	100 3/	700	0.3
Taxi	9,700	-	9,700	4.7
Other	6,100 4/	3,600 5/	9,700	4.9
TOTALS	140,900	63,800	204,700	100.0

1/ Employee vehicle trips plus vehicles to remote parking including Anza and Park-N-Fly lots.
2/ Greyhound and Airporter buses.
3/ UAL bus service.
4/ Airport shuttle bus, Anza and Park-N-Fly shuttle buses, and hotel/motel courtesy buses.
5/ Truck activity.

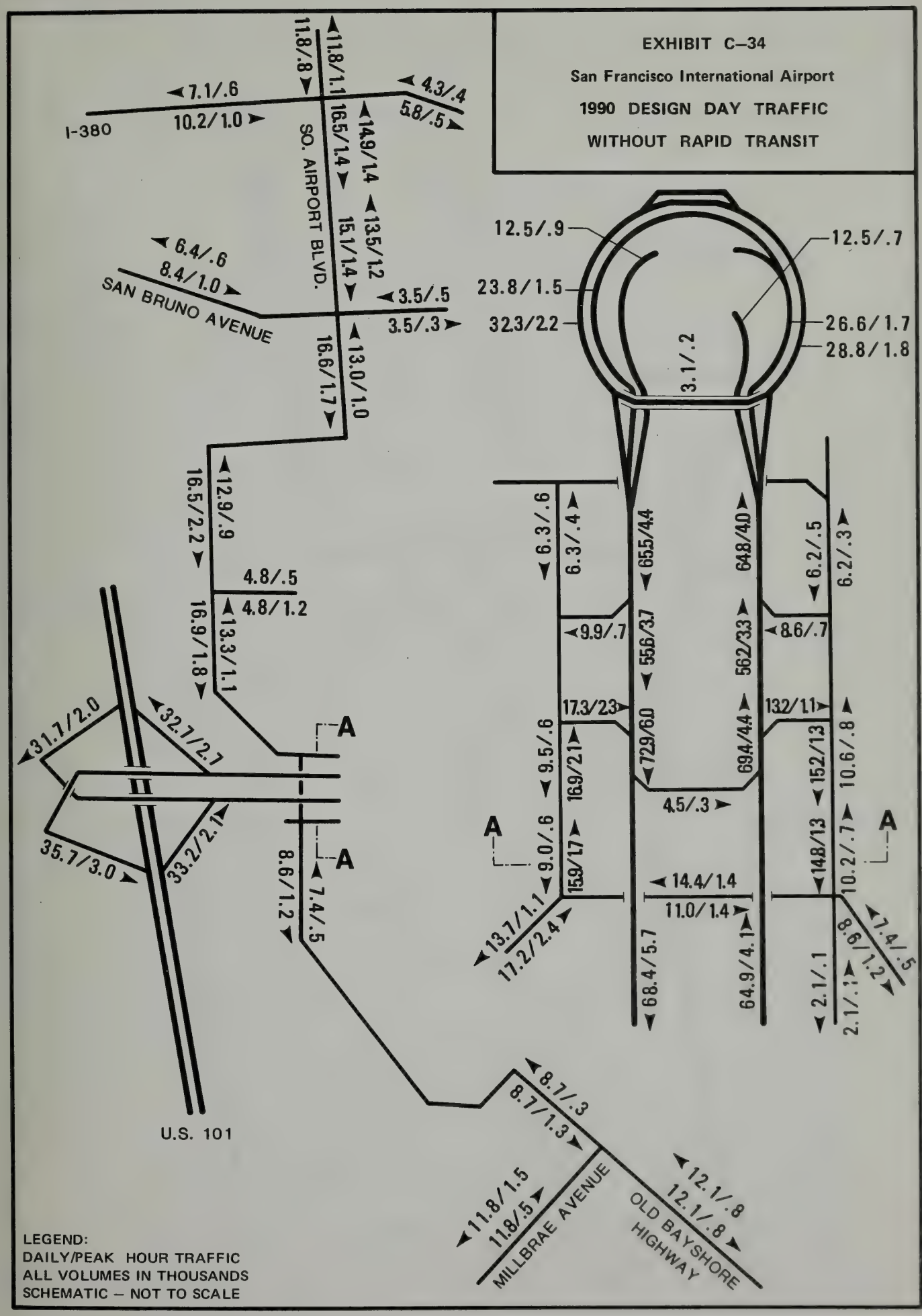


EXHIBIT C–34
San Francisco International Airport
1990 DESIGN DAY TRAFFIC
WITHOUT RAPID TRANSIT
I-380
SO. AIRPORT BLVD.
SAN BRUNO AVENUE
U.S. 101
MILLBRAE AVENUE
OLD BAYSHORE HIGHWAY
A
LEGEND:
DAILY/PEAK HOUR TRAFFIC
ALL VOLUMES IN THOUSANDS
SCHEMATIC – NOT TO SCALE

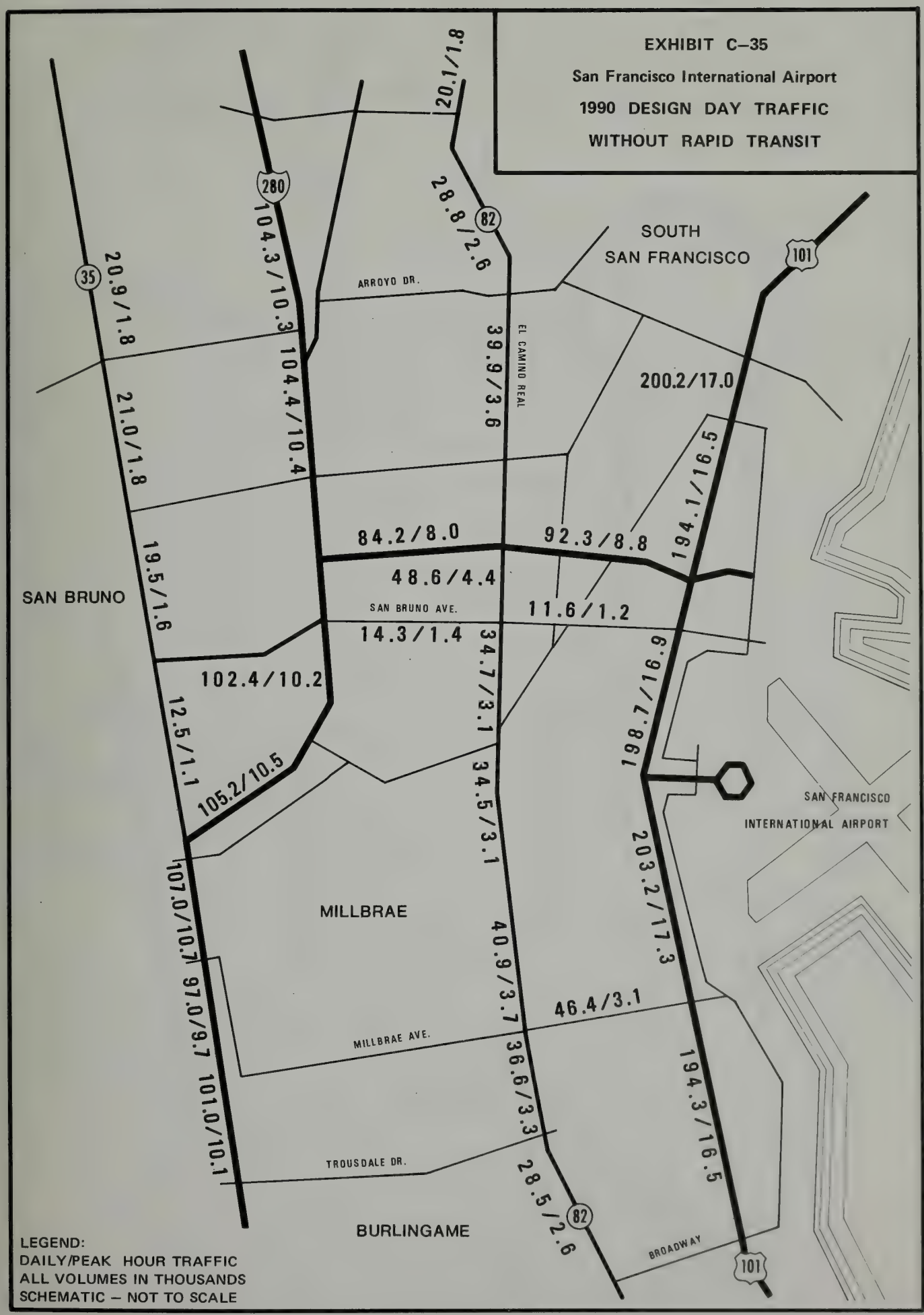


EXHIBIT C–35
San Francisco International Airport
1990 DESIGN DAY TRAFFIC
WITHOUT RAPID TRANSIT
SOUTH SAN FRANCISCO
SAN BRUNO
MILLBRAE
BURLINGAME
SAN FRANCISCO INTERNATIONAL AIRPORT
ARROYO DR.
SAN BRUNO AVE.
MILLBRAE AVE.
TROUSDALE DR.
BROADWAY
EL CAMINO REAL
280
82
35
101
20.1/1.8
28.8/2.6
104.3/10.3
104.4/10.4
39.9/3.6
20.9/1.8
21.0/1.8
19.5/1.6
84.2/8.0
92.3/8.8
48.6/4.4
14.3/1.4
11.6/1.2
34.7/3.1
102.4/10.2
12.5/1.1
105.2/10.5
107.0/10.7
97.0/9.7
101.0/10.1
34.5/3.1
40.9/3.7
46.4/3.1
36.6/3.3
28.5/2.6
200.2/17.0
194.1/16.5
6.9/7.8
203.2/17.3
194.3/16.5
LEGEND:
DAILY/PEAK HOUR TRAFFIC
ALL VOLUMES IN THOUSANDS
SCHEMATIC – NOT TO SCALE

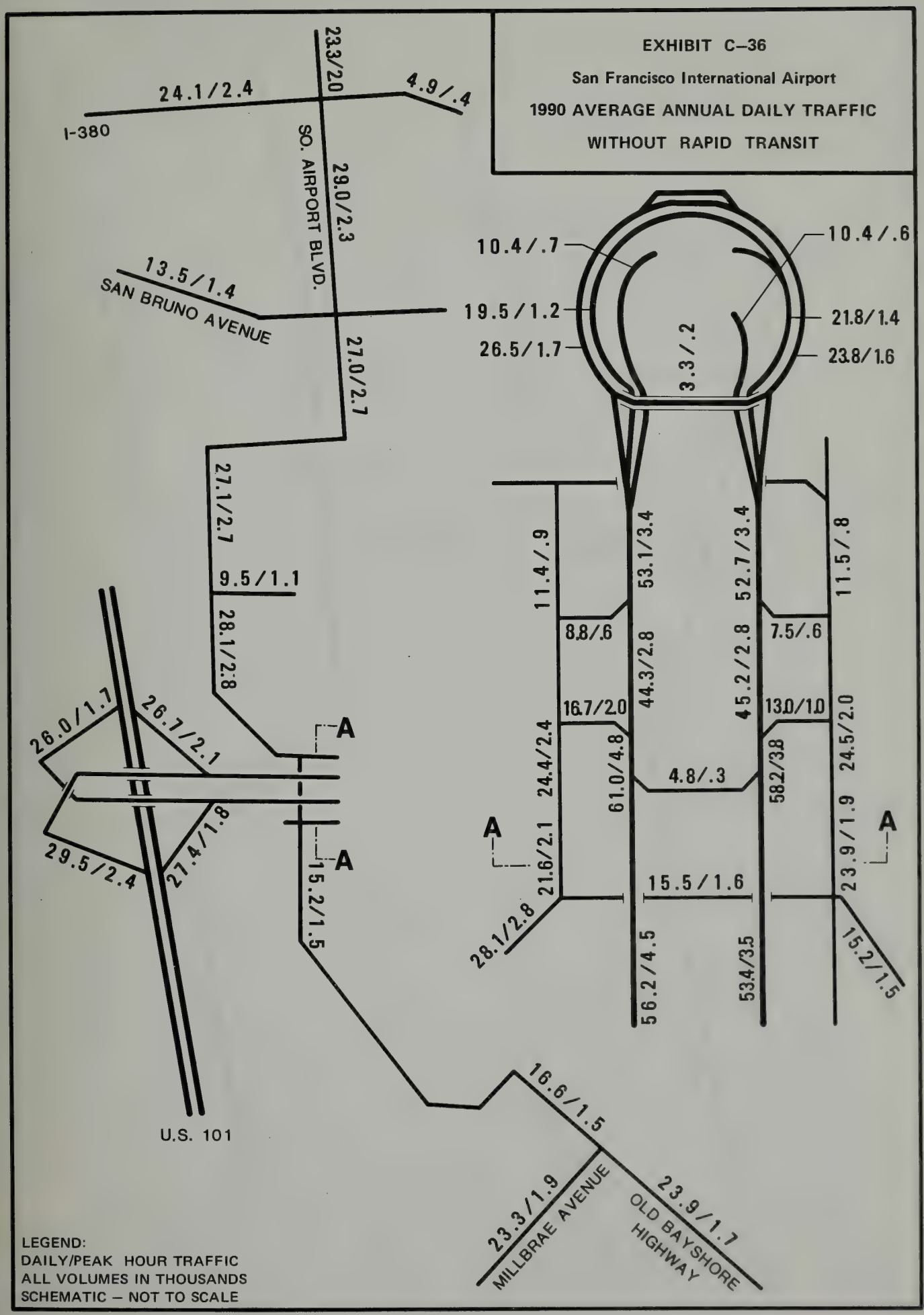


EXHIBIT C–36
San Francisco International Airport
1990 AVERAGE ANNUAL DAILY TRAFFIC
WITHOUT RAPID TRANSIT
I-380
24.1/2.4
23.3/2.0
4.9/.4
SO. AIRPORT BLVD.
29.0/2.3
13.5/1.4
SAN BRUNO AVENUE
27.0/2.7
27.1/2.7
9.5/1.1
28.1/2.8
26.0/1.7
26.7/2.1
29.5/2.4
27.4/1.8
A
A
A
A
15.2/1.5
U.S. 101
10.4/.7
19.5/1.2
26.5/1.7
3.3/.2
10.4/.6
21.8/1.4
23.8/1.6
11.4/.9
53.1/3.4
52.7/3.4
11.5/.8
8.8/.6
7.5/.6
16.7/2.0
44.3/2.8
45.2/2.8
13.0/1.0
24.4/2.4
61.0/4.8
4.8/.3
58.2/3.8
24.5/2.0
21.6/2.1
23.9/1.9
15.5/1.6
28.1/2.8
56.2/4.5
53.4/3.5
15.2/1.5
16.6/1.5
23.3/1.9
MILLBRAE AVENUE
23.9/1.7
OLD BAYSHORE HIGHWAY
LEGEND:
DAILY/PEAK HOUR TRAFFIC
ALL VOLUMES IN THOUSANDS
SCHEMATIC – NOT TO SCALE

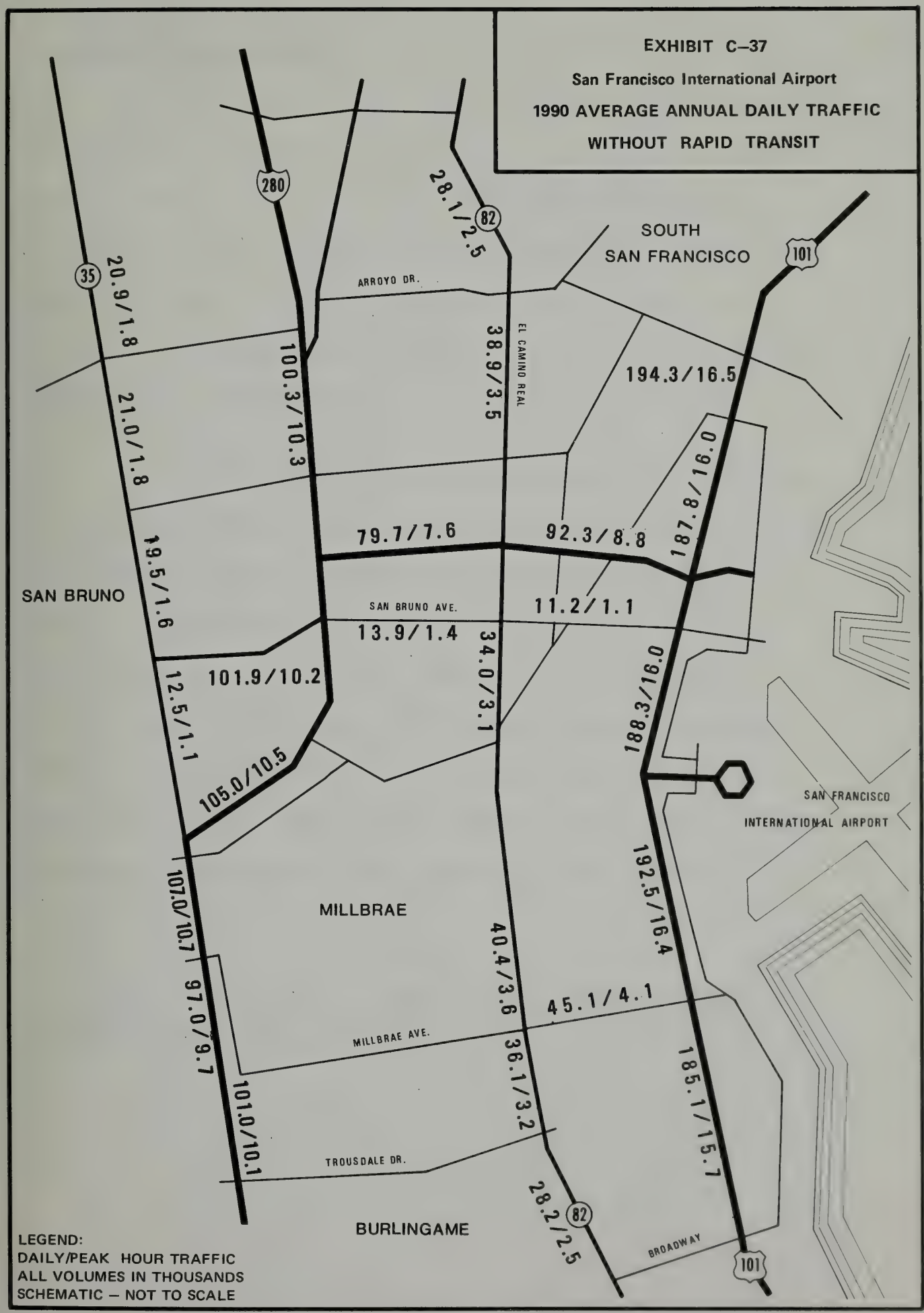


EXHIBIT C–37
San Francisco International Airport
1990 AVERAGE ANNUAL DAILY TRAFFIC
WITHOUT RAPID TRANSIT
280
82
35
101
20.9/1.8
21.0/1.8
19.5/1.6
28.1/2.5
100.3/10.3
38.9/3.5
EL CAMINO REAL
ARROYO DR.
SOUTH
SAN FRANCISCO
194.3/16.5
187.8/16.0
79.7/7.6
92.3/8.8
SAN BRUNO
SAN BRUNO AVE.
11.2/1.1
13.9/1.4
34.0/3.1
101.9/10.2
12.5/1.1
105.0/10.5
188.3/16.0
SAN FRANCISCO
INTERNATIONAL AIRPORT
MILLBRAE
107.0/10.7
97.0/9.7
40.4/3.6
192.5/16.4
45.1/4.1
MILLBRAE AVE.
36.1/3.2
185.1/15.7
101.0/10.1
TROUSDALE DR.
28.2/2.5
BURLINGAME
BROADWAY
LEGEND:
DAILY/PEAK HOUR TRAFFIC
ALL VOLUMES IN THOUSANDS
SCHEMATIC – NOT TO SCALE

Impact of Rapid Transit

It is assumed that rapid transit to San Francisco International Airport would take the form of a BART extension as spelled out in the 1972 final report of the San Francisco Airport Access Project.(1) This report endorses a subway alignment extension from Daly City directly into and through the airport. Exhibit C-38 illustrates the alignment recommended in that report.

Further, the airport access project study included a detailed assessment of the impact of rapid transit in terms of diverting travelers from other modes at the 31 million annual air passenger level. For an average weekday in 1990, these calculations show that 22,860 air passenger-related person trips plus 1,650 employee person trips would divert to rapid transit. Of the estimated 22,860 air passenger-related trips, 14,100 reflect diversions of air passengers (the balance being visitors, etc.). This

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(1) PBTB, Wilbur Smith, Kirker, Chapman, San Francisco Airport Access Project (Oakland, CA: PBTB, Wilbur Smith, Kirker, Chapman, October, 1972).

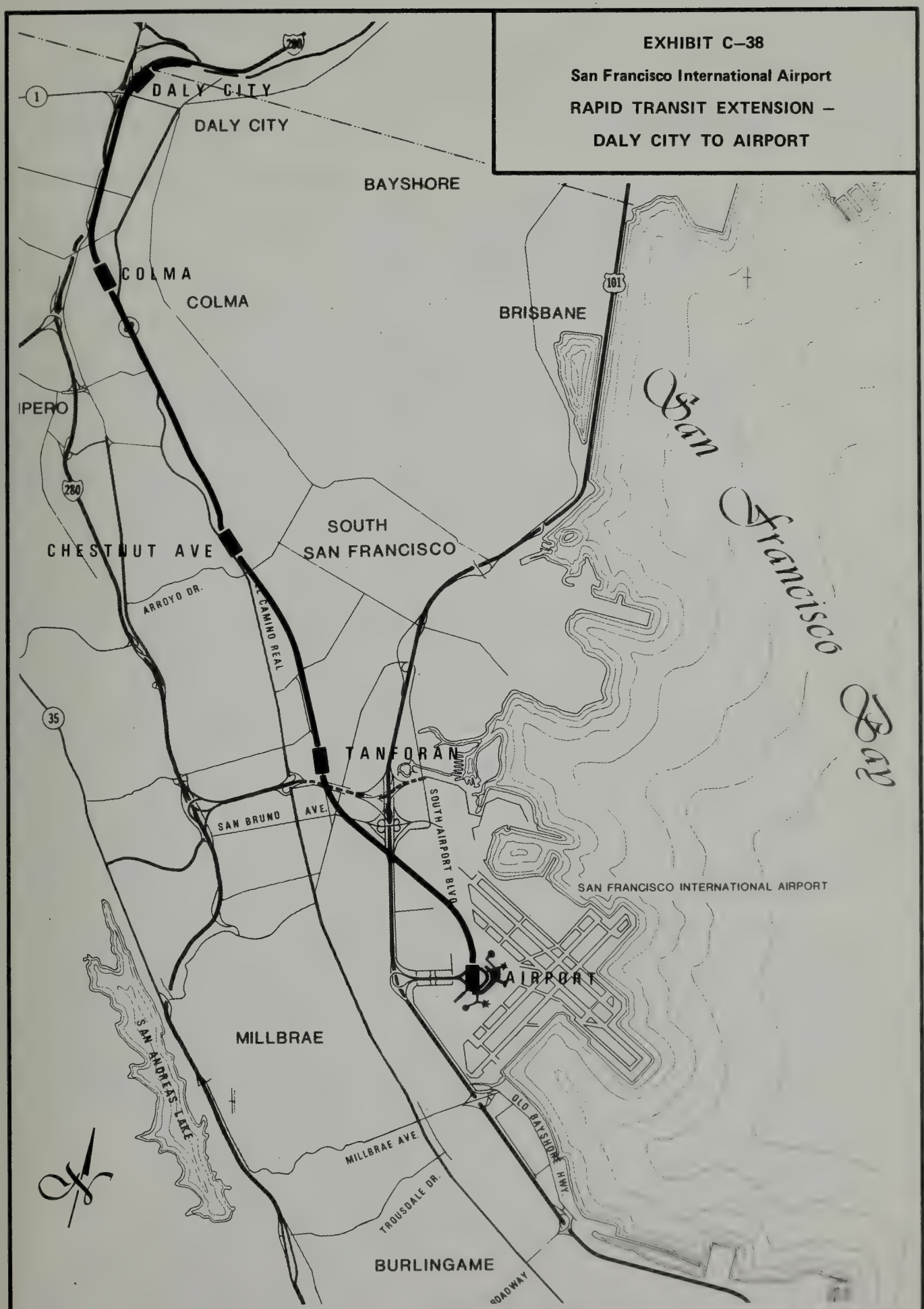


EXHIBIT C–38
San Francisco International Airport
RAPID TRANSIT EXTENSION –
DALY CITY TO AIRPORT
DALY CITY
DALY CITY
BAYSHORE
COLMA
COLMA
BRISBANE
IPERO
CHESTNUT AVE
SOUTH
SAN FRANCISCO
ARROYO DR.
EL CAMINO REAL
TANFORAN
SAN BRUNO AVE.
SOUTH AIRPORT BLVD.
SAN FRANCISCO INTERNATIONAL AIRPORT
AIRPORT
MILLBRAE
SAN ANDREAS LAKE
MILLBRAE AVE.
TROUSDALE DR.
OLD BAYSHORE HWY.
BURLINGAME
ROADWAY
San Francisco Bay
1
280
101
35

diversion approximates 17% of the annual average daily air passengers in 1990. The 1,650 employee trips diverted to rapid transit represents less than 2% of airport employment in 1990. It is interesting to note that approximately half the diversion to rapid transit (12,500 person trips) are diverted from trips formerly made by bus. The overall effect of the inclusion of rapid transit is that auto will still be the dominant access mode. Exhibit C-39 indicates that private auto, rental cars and taxis will represent 77.2% of total person trips on the 1990 design day. The major impact of a rapid transit extension (the report estimates) is that Airporter bus will lose approximately 75% of its patrons. Person trip diversions from auto drop this mode by only approximately 3%. In summary, the 24,600 total person trips diverted to rapid transit remove about 8,350 vehicle trips from roadways in and around the airport on the average day in 1990. The major impact is at the main Bayshore interchange with the terminal access road since the majority of rapid transit users are destined directly for the terminal complex. The vehicular travel which results after consideration of rapid transit diversions is indicated in Exhibit C-40.

EXHIBIT C-39

San Francisco International Airport

1990 DESIGN DAY MODE SPLIT DISTRIBUTION

TOTAL PERSON TRIPS WITH RAPID TRANSIT

Mode of Transportation	Air Passengers	Employees	Non-Air Passengers	Totals	Percent Distribution
Auto	44,600	71,600	85,700	201,900	73.6
Rental Auto	5,900	-	-	5,900	2.2
Bus	2,400	14,200	4,400	21,000	7.7
Taxi	3,900	-	-	3,900	1.4
Rapid Transit	20,300	1,700	2,600	24,600	9.0
Other	15,900	1,100	-	17,000	6.1
TOTALS	93,000	88,600	92,700	274,300	100.0

EXHIBIT C-40

San Francisco International Airport

1990 DESIGN DAY TOTAL VEHICLE TRIPS WITH RAPID TRANSIT

Mode of Transportation	Terminal Simulation	Rest of SFIA	Totals	Percent Distribution
Auto	113,200	59,000 1/	172,200	88.7
Rental Auto	4,600	-	4,600	2.4
Bus	400 2/	100 3/	500	0.3
Taxi	7,200	-	7,200	3.7
Other	6,100 4/	3,600 5/	9,700	4.9
TOTALS	131,500	62,700	194,200	100.0

1/ Employee vehicle trips plus vehicles to remote parking including Anza and Park-N-Fly lots.
2/ Greyhound and airporter buses.
3/ UAL bus service.
4/ Airport shuttle bus, Anza and Park-N-Fly shuttle buses, and hotel/motel courtesy buses.
5/ Truck activity.

The vehicular trips generated by each subgroup of airport population after consideration of rapid transit impacts were distributed to airport and regional roadway systems. The results of this distribution are indicated in Exhibits C-41, C-42, C-43 and C-44. The average annual daily traffic distributions are representative of the previously mentioned reduction of 8,350 two-way vehicular trips. In converting to the higher design day traffic estimates, this vehicular diversion amounts to 10,500 daily vehicles.

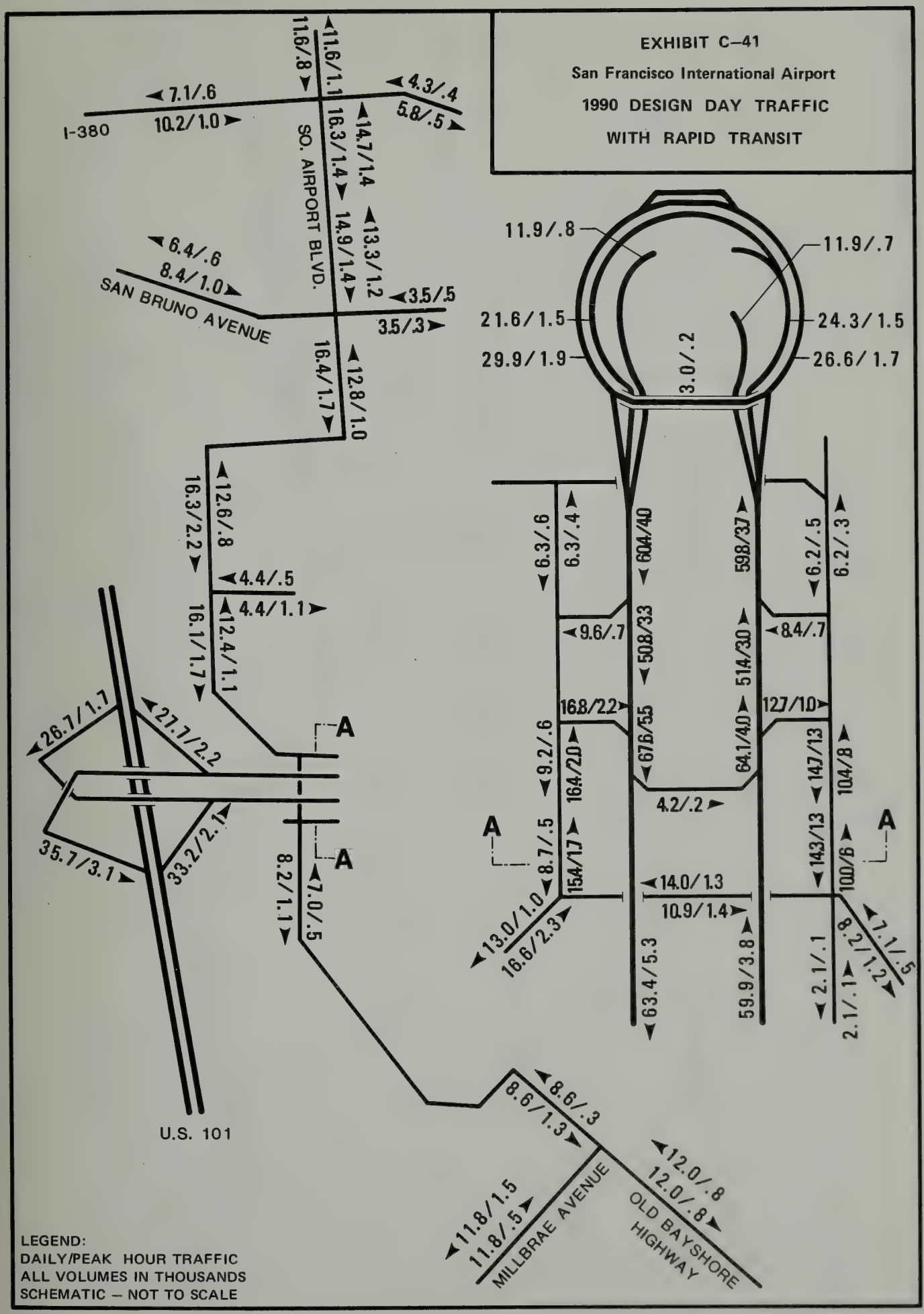


EXHIBIT C–41
San Francisco International Airport
1990 DESIGN DAY TRAFFIC
WITH RAPID TRANSIT
I-380
7.1/.6
10.2/1.0
11.6/.8
11.6/1.1
4.3/.4
5.8/.5
SO. AIRPORT BLVD.
16.3/1.4
14.7/1.4
14.9/1.4
13.3/1.2
SAN BRUNO AVENUE
6.4/.6
8.4/1.0
3.5/.5
3.5/.3
16.4/1.7
12.8/1.0
16.3/2.2
12.6/.8
4.4/.5
4.4/1.1
16.1/1.7
12.4/1.1
26.7/1.7
27.7/2.2
35.7/3.1
33.2/2.1
A
A
8.2/1.1
7.0/.5
U.S. 101
11.9/.8
11.9/.7
21.6/1.5
24.3/1.5
29.9/1.9
26.6/1.7
3.0/.2
6.3/.6
6.3/.4
60.4/40
59.8/37
6.2/.5
6.2/.3
9.6/.7
50.8/33
51.4/30
8.4/.7
16.8/2.2
67.6/55
64.1/40
12.7/10
9.2/.6
16.4/2.0
14.7/13
10.4/8
4.2/.2
A
A
8.7/.5
15.4/1.7
14.3/13
10.0/6
14.0/1.3
10.9/1.4
13.0/1.0
16.6/2.3
63.4/5.3
59.9/3.8
2.1/.1
2.1/.1
1.2/.8
1.1/.5
2.1/.2
8.6/.3
8.6/1.3
12.0/.8
12.0/.8
11.8/1.5
11.8/.5
MILLBRAE AVENUE
OLD BAYSHORE HIGHWAY
LEGEND:
DAILY/PEAK HOUR TRAFFIC
ALL VOLUMES IN THOUSANDS
SCHEMATIC – NOT TO SCALE

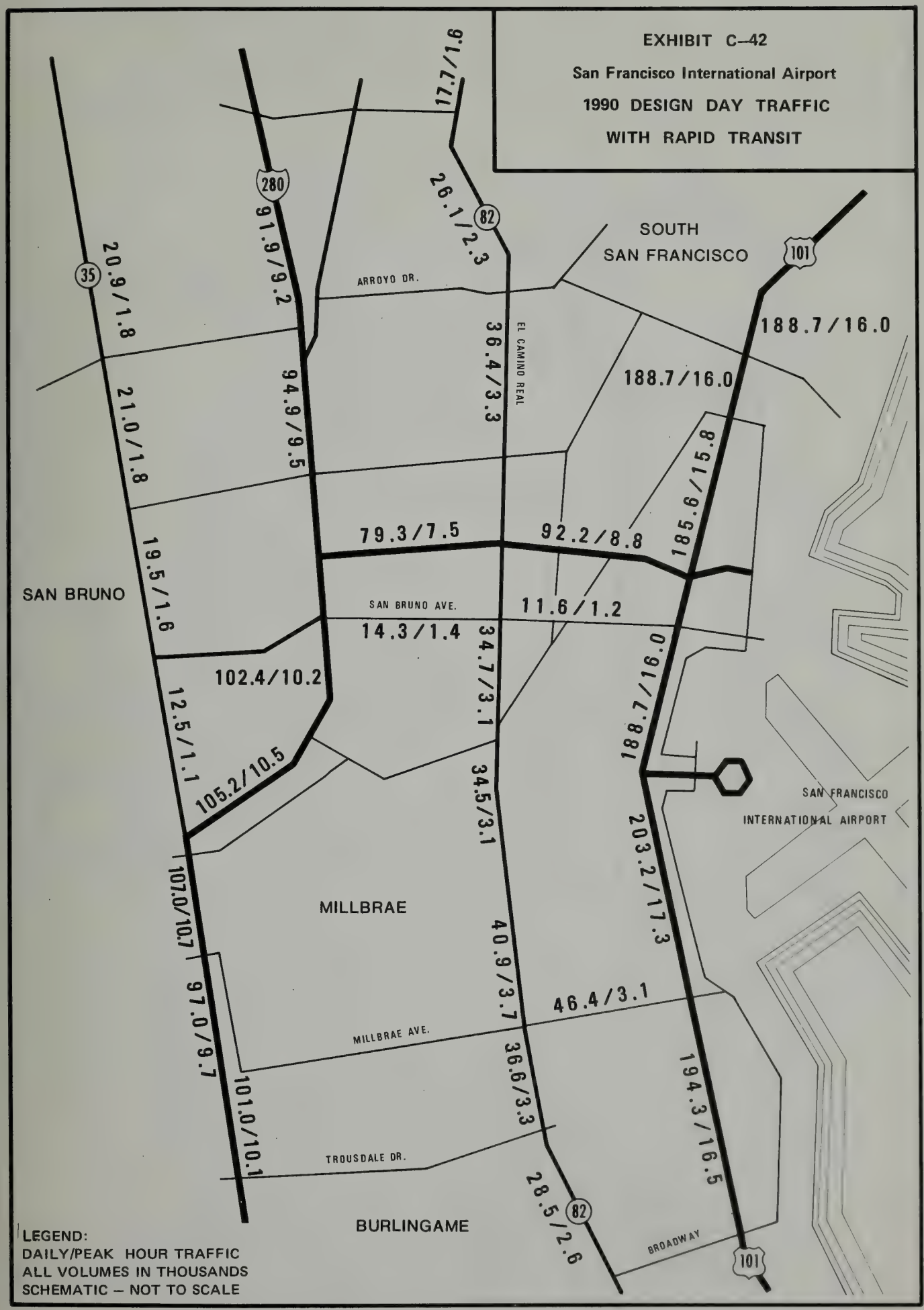


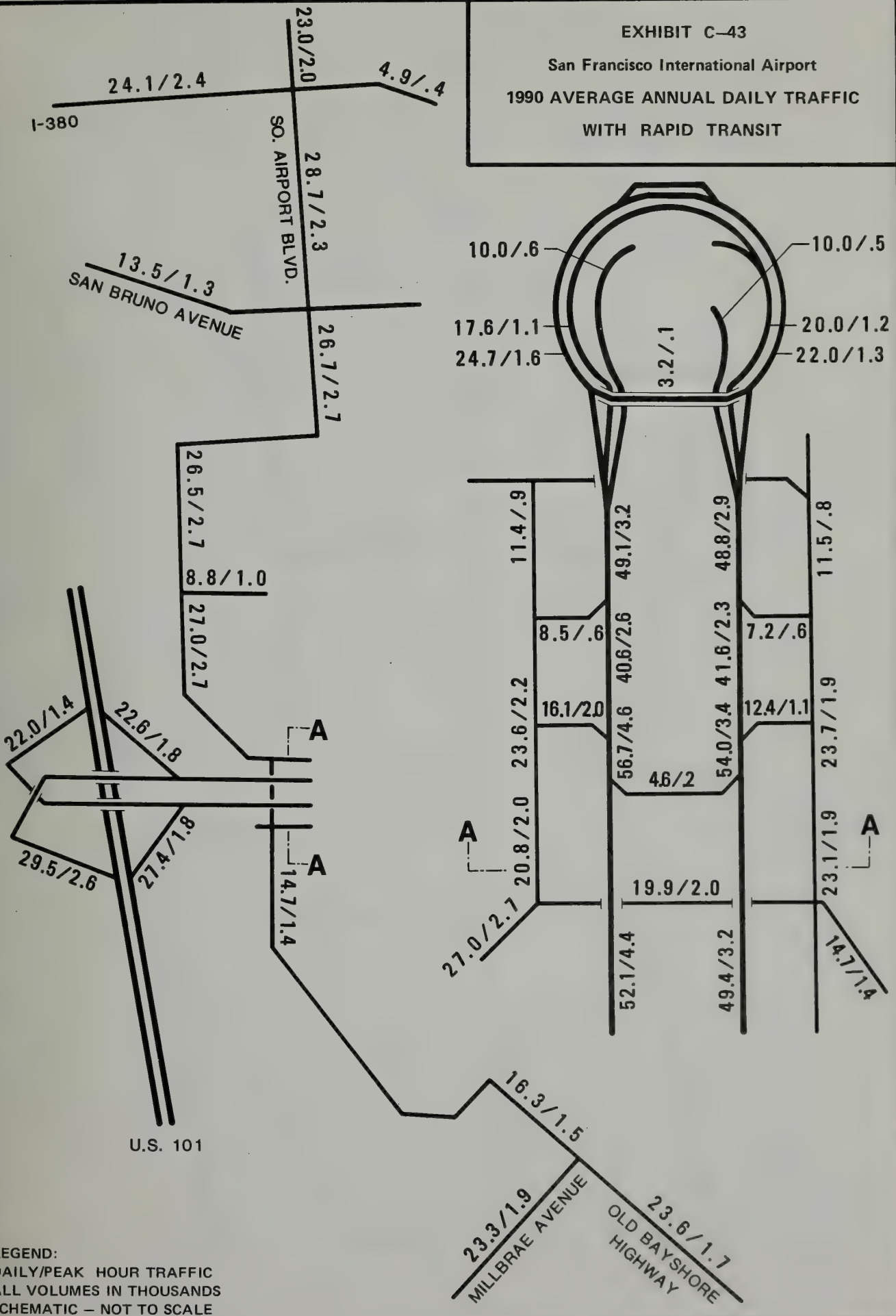
EXHIBIT C–42
San Francisco International Airport
1990 DESIGN DAY TRAFFIC
WITH RAPID TRANSIT
280
35
82
101
SOUTH
SAN FRANCISCO
ARROYO DR.
EL CAMINO REAL
SAN BRUNO
SAN BRUNO AVE.
MILLBRAE
MILLBRAE AVE.
TROUSDALE DR.
BURLINGAME
BROADWAY
SAN FRANCISCO
INTERNATIONAL AIRPORT
9.1/1.71
91.9/9.2
26.1/2.3
20.9/1.8
21.0/1.8
94.9/9.5
36.4/3.3
188.7/16.0
188.7/16.0
185.6/15.8
79.3/7.5
92.2/8.8
19.5/1.6
14.3/1.4
11.6/1.2
102.4/10.2
34.7/3.1
0.9/7.88
12.5/1.1
105.2/10.5
34.5/3.1
203.2/17.3
107.0/10.7
40.9/3.7
46.4/3.1
97.0/9.7
36.6/3.3
194.3/16.5
101.0/10.1
28.5/2.6
LEGEND:
DAILY/PEAK HOUR TRAFFIC
ALL VOLUMES IN THOUSANDS
SCHEMATIC – NOT TO SCALE

EXHIBIT C–43

San Francisco International Airport

1990 AVERAGE ANNUAL DAILY TRAFFIC

WITH RAPID TRANSIT



LEGEND:
DAILY/PEAK HOUR TRAFFIC
ALL VOLUMES IN THOUSANDS
SCHEMATIC – NOT TO SCALE

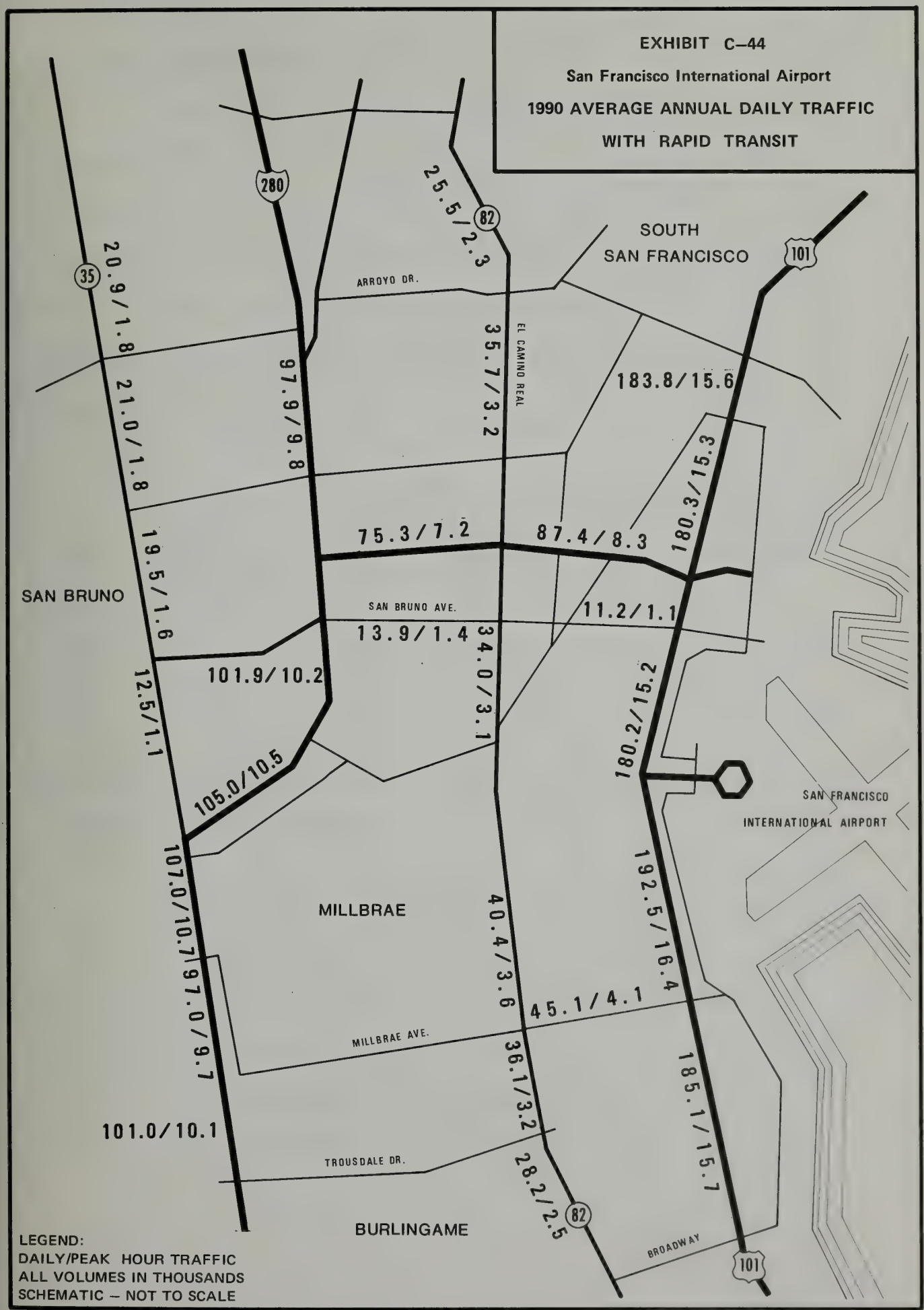


EXHIBIT C–44
San Francisco International Airport
1990 AVERAGE ANNUAL DAILY TRAFFIC
WITH RAPID TRANSIT
280
82
35
101
SOUTH
SAN FRANCISCO
ARROYO DR.
EL CAMINO REAL
SAN BRUNO
SAN BRUNO AVE.
MILLBRAE
MILLBRAE AVE.
TROUSDALE DR.
BURLINGAME
BROADWAY
SAN FRANCISCO
INTERNATIONAL AIRPORT
25.5/2.3
20.9/1.8
21.0/1.8
97.9/9.8
35.7/3.2
183.8/15.6
180.3/15.3
75.3/7.2
87.4/8.3
19.5/1.6
11.2/1.1
13.9/1.4
34.0/3.1
101.9/10.2
12.5/1.1
180.2/15.2
105.0/10.5
107.0/10.7
97.0/9.7
40.4/3.6
192.5/16.4
45.1/4.1
36.1/3.2
185.1/15.7
101.0/10.1
28.2/2.5
LEGEND:
DAILY/PEAK HOUR TRAFFIC
ALL VOLUMES IN THOUSANDS
SCHEMATIC – NOT TO SCALE

7. IMPACT ASSESSMENT

Each of the previously described traffic volume estimates has been used to assess the impacts from a traffic standpoint in and around the airport. The combination of traffic estimates with roadway, intersection, parking and curb frontage capacities provides the information for performing nine basic impact analyses. These nine can be summarized as follows:

Year	Annual Air Passengers (millions)	Rapid Transit		Terminal Improvements	
		None	Extended	None	As Proposed
1974	16.2	X		X	
1982	24.4	X		X	X
1990	31.0	X	X	X	X

For each of these nine basic cases, six impact items were examined. These include:

1. on-airport intersection capacities
2. off-airport intersection capacities
3. weaving capacity - main entrance road
4. public parking sufficiency
5. terminal curb frontage needs
6. off-airport highway capacities.

A further variation in the analysis of these six items involves the need to review their sufficiency at different hours of the day since peak traffic hours of non-airport traffic do not coincide with peak traffic hours for airport traffic. Therefore, where appropriate, the six impact items were examined for three time periods - - 3 to 4 P. M., 5 to 6 P. M. and 7 to 8 P. M. This process assures that each impact item will be examined under its respective peak hour conditions. The net result of this need to examine nine basic cases for six impact items in three time periods is the potential need to perform 162 permutations of impact analyses. The remainder of this section treats each of these permutations chronologically beginning with baseline conditions in 1974.

Existing Conditions

The 1974 impact assessment provides a baseline case and was completed with no changes to the existing roadways, intersections, ramps, frontage road, parking facilities or public transit. The results for each impact assessment item include:

- On-airport intersections have been classified in accordance with the letter-number designation utilized by the airport. These designations are illustrated in Exhibit C-45 and result in a need to consider the following intersections: R2 and R16; R1 and R18; R3 and R18; R1 and R16; and R6 and the frontage road. In the case of these internal intersections, examination has been confined to the peak hour for airport employee traffic (3 to 4 P. M.). Exhibit C-46 shows the results of this comparison of intersection volume with capacities and illustrates the level of service for each intersection (see Methodology section for definition of level of service). It is evident from the chart that four of the five intersections operate in virtually free flow conditions with the intersection of R3 and R18 operating at a reasonable design level of service C. The conclusion being that all on-airport intersections are adequate for peak hour design day traffic in 1974.

EXHIBIT C–45

San Francisco International Airport

ON–AIRPORT ROADWAY DESIGNATIONS

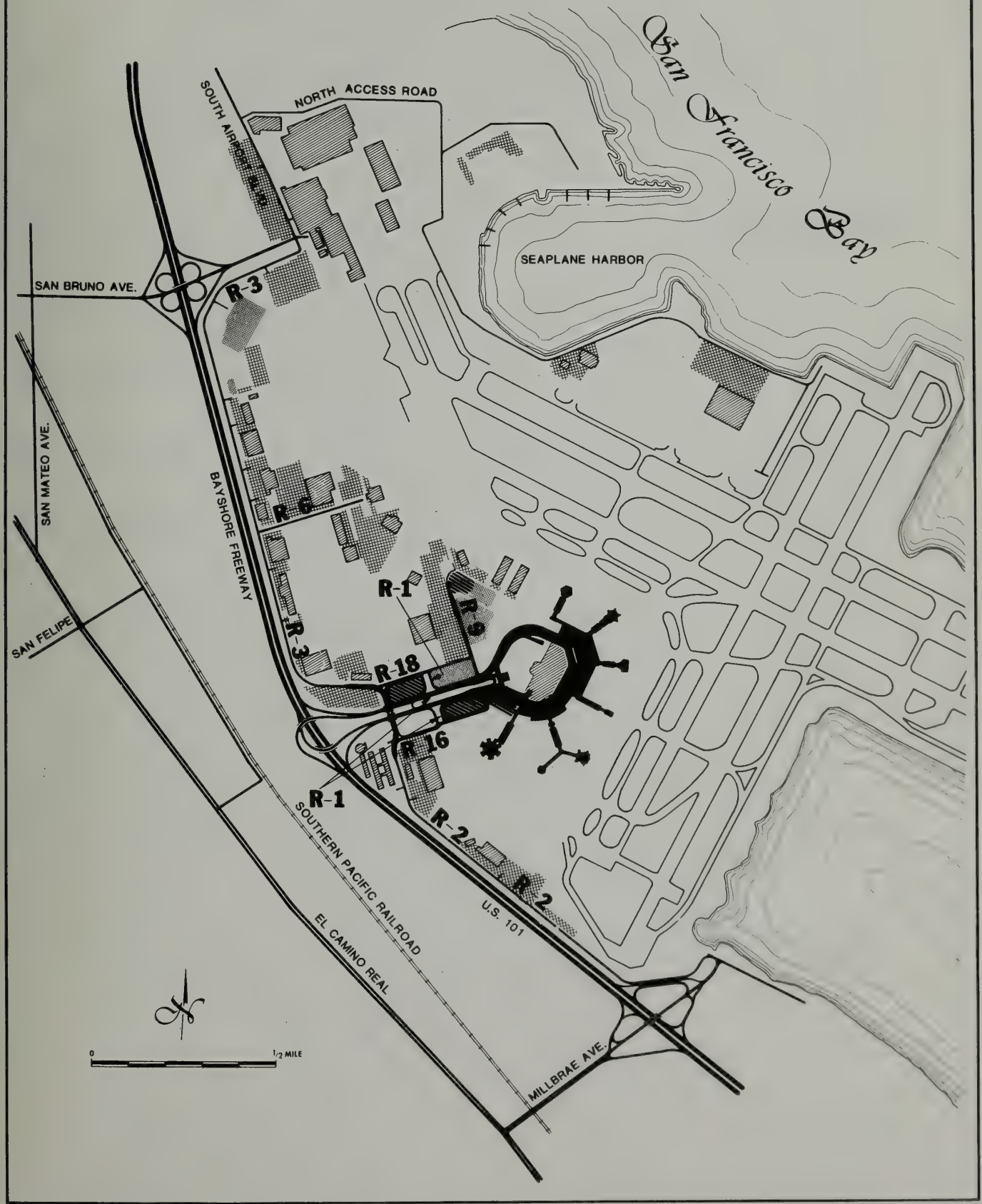


EXHIBIT C-46

San Francisco International Airport

1974 DESIGN DAY PEAK HOUR

ON-AIRPORT INTERSECTION CAPACITY ANALYSIS

Intersection	Level of Service
R-1 and R-16	A
R-1 and R-18	A
R-2 and R-16	A
R-3 and R-18	C
R-3 and R- 6	A

- Off-airport intersections include Millbrae Avenue and Old Bayshore Road, South Airport Boulevard and North Access Road, South Airport Boulevard and San Bruno Avenue, Millbrae Avenue and El Camino Real, 2nd San Bruno Avenue and El Camino Real. In this case, because of the combination of airport-related traffic and non-airport-related traffic, these intersections were examined for all three time periods - - 3 to 4 P. M., 5 to 6 P. M. and 7 to 8 P. M. Exhibit C-47 illustrates similar level of service results for the five off-airport intersections for each peak hour period. The results of this analysis indicate that all intersections operate at or above design capacity levels with the exception of the El Camino Real-San Bruno Avenue intersection during the 5 to 6 P. M. highway peak period. It is interesting to note that the composition of traffic at this intersection involves only 21% airport-related travel in the highway peak hour as compared with 46% and 32% respectively in the peak employee and air passenger activity period.

EXHIBIT C-47

San Francisco International Airport

1974 EXISTING CONDITIONS

OFF-AIRPORT INTERSECTION CAPACITY ANALYSIS

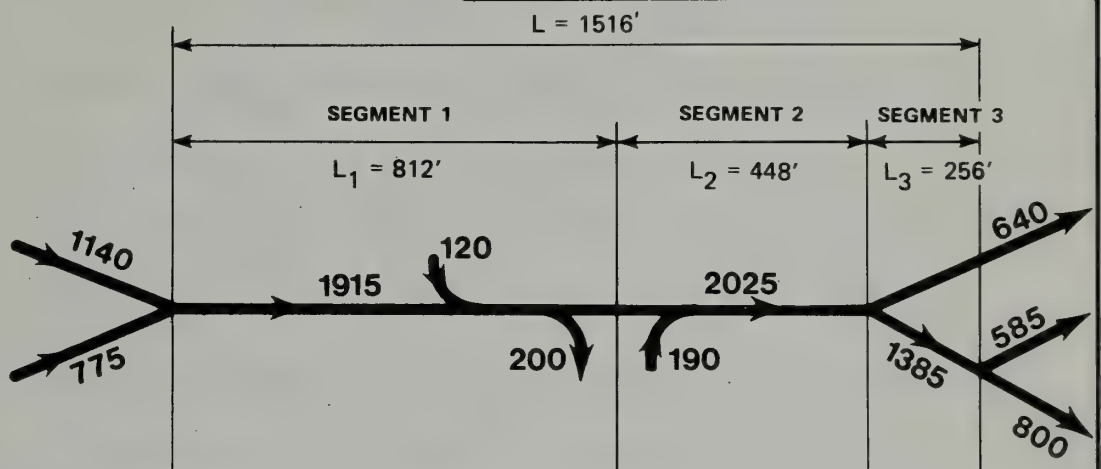
Intersection	Level of Service		
	3-4 P.M.	5-6 P.M.	7-8 P.M.
San Bruno Avenue & South Airport Blvd.	C	A	A
North Access Road & South Airport Blvd.	A	A	A
Millbrae Avenue & Old Bayshore Highway	A	A	A
El Camino Real & San Bruno Avenue	C	D	A
El Camino Real & Millbrae Avenue	B	B	A

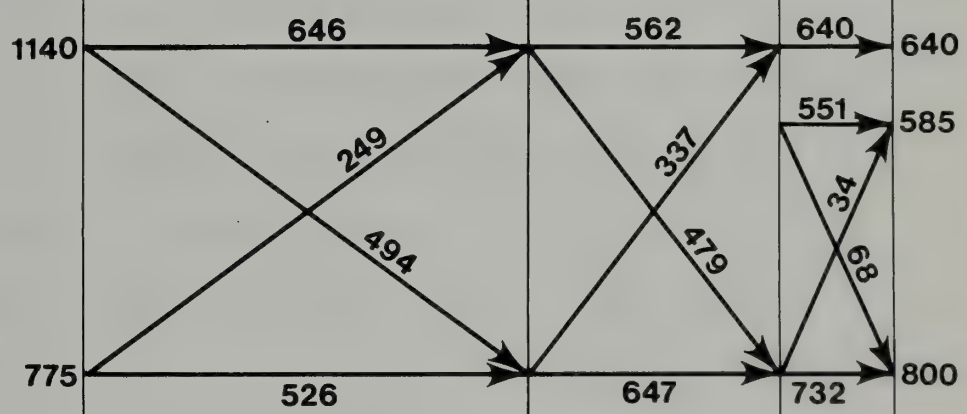
EXHIBIT C–48

San Francisco International Airport

1974 DESIGN DAY PEAK HOUR

WEAVING SECTION ANALYSIS-MAIN ACCESS ROADWAY





WEAVING SECTION ANALYSIS

Total Roadway Volume (VPH)	1915	2025	1385
Total Weaving Volume (VPH)	743	816	102
For Roadway Level of Service	A	A	A
– Service Volume Per Lane (VPH)	800	850	800
– Required Number of Lanes	2.9	3.2	
Existing Number of Lanes	3	4	3
Level Of Service Of Weaving Volume	C	C	
Overall Roadway Level of Service	C	C	A

- Weaving capacity of main entrance road is similarly measured in terms of quality of flow. In the case of a weaving section, this is measured through the length of the section, the number of lanes in this section and the total volume of weaving vehicles. Since the main entrance roadway is functioning as a multiple-weaving section, the analysis has been completed for three segments as shown in Exhibit C-48. Traffic entering the main roadway from the north (1,140 peak vehicles) and the south (775 vehicles) from Bayshore Freeway will accomplish their weaving movements in each segment in direct proportion to that segment's weaving length to the overall weaving length (1516 feet). Additionally, movements from the lower recirculation roadway and to and from the ramps leading to internal road R16 have been assigned to the segments according to their respective origins and destinations. In the case of the main roadway capacity analysis, the governing factor is overall roadway level of service. Exhibit C-48

EXHIBIT C-49

San Francisco International Airport

PARKING GENERATION FACTORS

	Long-Term Parking 1, 2/	Short-Term Parking 1, 2/
Business Enplanements	0.153	0.030
Non-Business Enplanements	0.012	0.270
Business Deplanements	3/	0.150
Non-Business Deplanements	3/	0.350

1/ Number of parked vehicles per air passenger
2/ Does not include parking for purposes other than air passenger travel.
3/ Long-term parking generation is essentially the same, based on either enplanements of deplanements. However, generation should be computed using either one or the other, to avoid "double counting."

Ref: ( )

EXHIBIT C-50

San Francisco International Airport

RATIOS OF PEAK ACCUMULATIONS TO TOTAL WEEKLY PARKERS

	Long-Term	Short-Term
Wednesday, December 3, 1969		
12:00 Noon	0.296	0.0083
9:00 P.M.	0.221	0.0098
Thursday, December 4, 1969		
12:00 Noon	0.282	0.0083
9:00 P.M.	0.221	0.0098
Friday, December 5, 1969		
12:00 Noon	0.250	0.0098
7:00 P.M.	0.243	0.0189
Saturday, December 6, 1969		
12:00 Noon	0.219	0.0168

Total parkers for week of December 1-7, 1969:

Long-Term	13,000
Short-Term	27,800

Ref: ( )

illustrates the details of weaving and non-weaving traffic for each segment and shows that overall roadway level of service meets and exceeds design expectations for each segment. This indicates that during the 1974 design day, there should be no reason for backup onto the ramps leading to the Bayshore Freeway.

- Public parking analysis has been accomplished in accordance with the estimating techniques set forth in the Methodology section. As pointed out there, the key characteristics involve trip purpose, seasonal patterns, mix of long- and short-term parking, non-air passenger-related parking, parking generation factors (Exhibit C-49) and the ratios of peak accumulation to total weekly parking (Exhibit C-50). Parking computations are based on a typical week during the peak traffic month of August which contains 10.6% of annual air passengers (1,720,500). Utilizing these factors and accounting for transfer passengers, yields 168,100 enplanements

and 172,100 deplanements. Business-related travel (41%) represents 68,900 enplanements and 70,600 deplanements, leaving non-business enplanements/deplanements at 99,200 and 101,600, respectively. Non-air passenger-related parking will require 2,340 long-term spaces. Exhibit C-51 has been prepared utilizing the parking generation factors cited in the Methodology source information. This exhibit indicates a demand for 14,357 long-term parkers and 79,220 short-term parkers. Using the ratios of parking accumulation to total weekly parkers, it is possible to convert these demands to accumulated parked vehicles which sets the need for parking spaces. The results of this conversion are illustrated in Exhibit C-52 with peak accumulation occurring on a Friday at 7:00 P. M. with a maximum accumulation of 4,986 parkers or 73.6% of the available 6,779 public parking spaces. For each hour shown in Exhibit C-52, garage capacity (3,000 spaces)

EXHIBIT C-51

San Francisco International Airport

1974 EXISTING CONDITIONS

AIRPORT PARKERS FOR TYPICAL WEEK IN AUGUST

	Long-Term Parking	Short-Term Parking
Business Enplanements	-	2,068
Non-Business Enplanements	-	26,779
Business Deplanements	10,798	10,587
Non-Business Deplanements	1,219	35,546
Subtotal	12,017	74,980
Non-Air Passenger-Related Parking	2,340	4,240
TOTAL	14,357	79,220

EXHIBIT C-52

San Francisco International Airport

1974 GARAGE ANALYSIS ACCUMULATION OF PARKED VEHICLES

	Long-Term	Short-Term	Total
Wednesday			
12:00 Noon	4,250	658	4,908
9:00 P.M.	3,173	776	3,949
Thursday			
12:00 Noon	4,049	658	4,707
9:00 P.M.	3,173	776	3,949
Friday			
12:00 Noon	3,589	776	4,365
7:00 P.M.	3,489	1,497	4,986
Saturday			
12:00 Noon	3,144	1,331	4,475

would need to be supplemented through usage of additional public parking in Lot B (334 spaces), Lot 2 (845 spaces) and Lot D (2,600 spaces).

- Curb frontage analysis - This case is analyzed for the existing south and central terminals. The enplaning roadway fronting the south terminal services 464 vehicles and 735 air passengers requiring 21,538 foot minutes of curb space or 32.5% of possible capacity of curb frontage (Exhibit C-53). A similar analysis for the south terminal deplaning curb frontage is shown in Exhibit C-54 and indicates frontage requirements at 55% of possible capacity. Similar analyses of the central terminal are developed in Exhibit C-55 and Exhibit C-56 which show a need for 47.4% of the possible capacity for enplaning curb frontage and 82.7% of possible capacity for deplaning curb frontage. In both cases, the characteristics and volumes on the enplaning roadway require less curb frontage

EXHIBIT C-53

San Francisco International Airport

1974 CURB FRONTAGE ANALYSIS ENPLANING ROADWAY-SOUTH TERMINAL

Type of Vehicle	Number of Vehicles	Average Air Passengers Per Vehicle	Deplaning Air Passengers Per Hour	Average( ) Foot Minutes Per Vehicle	Foot Minutes Required
Auto	286	1.1	315	50	14,300
Taxi	21	1.45	30	30	630
Hotel/Limo	150	2.0	300	42	6,300
Bus	7	12.8	90	44	308
	464		735		21,538

* * * *

EXHIBIT C-54

San Francisco International Airport

1974 CURB FRONTAGE ANALYSIS DEPLANING ROADWAY-SOUTH TERMINAL

Type of Vehicle	Number of Vehicles	Average Air Passengers Per Vehicle	Deplaning Air Passengers Per Hour	Average( ) Foot Minutes Per Vehicle	Foot Minutes Required
Auto	431	1.1	474	75	32,325
Taxi	38	1.9	72	50	1,900
Hotel/Limo	102	2.4	245	56	5,712
Bus	13	8.8	114	88	1,144
	584		905		41,081

* * * *

EXHIBIT C-55

San Francisco International Airport

1974 CURB FRONTAGE ANALYSIS ENPLANING ROADWAY-CENTRAL TERMINAL

Type of Vehicle	Number of Vehicles	Average Air Passengers Per Vehicle	Deplaning Air Passengers Per Hour	Average( ) Foot Minutes Per Vehicle	Foot Minutes Required
Auto	429	1.1	472	50	21,450
Taxi	31	1.45	45	30	930
Hotel/Limo	150	3.0	450	63	9,450
Bus	7	19.2	134	66	462
	617		1,101		32,292

* * * *

EXHIBIT C-56

San Francisco International Airport

1974 CURB FRONTAGE ANALYSIS DEPLANING ROADWAY-CENTRAL TERMINAL

Type of Vehicle	Number of Vehicles	Average Air Passengers Per Vehicle	Deplaning Air Passengers Per Hour	Average( ) Foot Minutes Per Vehicle	Foot Minutes Required
Auto	646	1.1	711	75	48,450
Taxi	56	1.9	106	50	2,800
Hotel/Limo	102	3.6	367	84	8,568
Bus	13	13.2	172	132	1,716
	817		1,356		61,534

* *

Possible Capacity = (1,240 ft.) x (60 min.) = 74,400 ft. min.

Practical Capacity = (70%) x (74,400) = 52,080 ft. min.

Required Curb Frontage = 61,534 ft. min.

Curb Frontage Usage = 82.7% of Possible Capacity

Ref: ( )

than the deplaning roadway due to higher demand volumes and longer dwell times at deplaning curbs. Consequently, deplaning curb frontage is the most vulnerable component of the airport ground access system with high probability of delays. For this reason, it is useful to examine the demand/capacity relationship from the standpoint of a more practical capacity than the maximum possible capacity. The accepted standard for practical curb frontage capacity is 70% of possible since it has been demonstrated that demand in excess of the 70% figure usually results in double parking, illegal use of reserved curbs or excessive walking distances for air passengers. Under that standard, the deplaning roadway at the central terminal shows usage in excess of the practical capacity level and, therefore, experiences some of the problems enumerated above. All remaining curb frontages function with a minimum of interference to circulating vehicles.

- Off-airport highway capacity has been examined through similar methods of comparison of volumes to available capacities. In the case of the off-airport intersections previously enumerated, examination of impacts was made for three critical peak hours on the design day including 3 to 4 P. M., 5 to 6 P. M. and 7 to 8 P. M. The results of the volume/capacity analysis and resultant levels of service for all the locations during the three critical peak periods is presented in Exhibit C- 57. All intersections operate at better than acceptable levels of service with the exception of the Bayshore Freeway on either side of the airport ramps, both north and southbound during the 5 to 6 P. M. traffic peak. Northbound traffic operates at level of service D upstream and downstream from the intersection while southbound the Freeway operates at level of service E north of the ramps and D south of the ramps. It is important to note that during this peak hour (which is not the airport

EXHIBIT C-57

San Francisco International Airport

1974 DESIGN DAY

OFF-AIRPORT HIGHWAY UTILIZATION

Facility/Location	Capacity (One-Way)	3-4 P.M. Volume	3-4 P.M. V/C	3-4 P.M. L of S	5-6 P.M. Volume	5-6 P.M. V/C	5-6 P.M. L of S	7-8 P.M. Volume	7-8 P.M. V/C	7-8 P.M. L of S
Freeway										
Bayshore Freeway										
So. of Airport Ramps (Northbound)	8,000	5,600	.70	C	6,700	.84	D	4,600	.58	B
So. of Airport Ramps (Southbound)	8,000	6,200	.78	C	7,200	.90	D	4,600	.58	B
No. of Airport Ramps (Northbound)	8,000	5,800	.73	C	6,900	.86	D	4,700	.59	B
No. of Airport Ramps (Southbound)	8,000	6,400	.80	C	7,400	.93	E	4,700	.59	B
Interchanges										
Bayshore Freeway										
Airport - SB-FR/Airport	1,800	1,300	.72	C	850	.47	B	830	.46	B
SB-TO/Airport	1,800	1,100	.61	B	980	.54	B	1,140	.63	B
NB-FR/Airport	1,800	1,500	.83	C	1,060	.59	B	1,500	.83	C
NB-TO/Airport	1,800	900	.50	B	830	.46	B	775	.43	A
San Bruno Avenue - SB-FR/Airport	1,300	900	.69	C	800	.62	B	450	.35	A
SB-TO/Airport	1,300	300	.23	A	250	.19	A	100	.08	A
NB-FR/Airport	1,800	250	.14	A	200	.11	A	150	.08	A
NB-TO/Airport	1,800	450	.25	A	200	.11	A	50	.03	A
Millbrae Avenue - SB-FR/Airport	1,500	900	.60	B	600	.40	A	400	.27	A
SB-TO/Airport	500	200	.40	A	250	.50	B	100	.20	A
NB-FR/Airport	1,800	900	.50	B	850	.47	B	350	.19	A
NB-TO/Airport	1,800	500	.28	A	550	.31	A	250	.14	A

peak hour), the percentages of airport-related traffic range from 18% to 22% upstream and downstream from the ramps. On the other hand, during the peak air passenger period (7 to 8 P. M.) when airport-related travel approximates 40% of the traffic flow, all the Bayshore Freeway links under consideration operate at level of service B.

1982 Conditions

A companion analysis for the existing impact conditions has been prepared for 1982 at the 24.4 million air passenger level. This analysis differs from 1974 in that several traffic improvements to the roadway system have been incorporated including the widening of internal road R3 to four lanes, the widening of Old Bayshore Road to allow for a double left-turn lane at its intersection with Millbrae Avenue, the construction of I-380 linking South Airport Boulevard with I-280 (including interchanges with the Bayshore Freeway and El Camino Real) and the construction of two-lane ramps at the airport interchange with the Bayshore Freeway.

Further, an additional option has been assessed relating to the consequences of not constructing planned airport improvements. Those improvements include completion of the north terminal, the expansion of the existing parking garage to 7,300 spaces and improvements to lower roadway recirculation. Therefore, the 1982 impact analysis has been performed with and without these improvements. Results include:

- On-airport intersections in the 1982 volume conditions operate above design levels of service with the exception of the intersection of R3 and R18 which operates at level of service D (Exhibit C-58). Examination of this intersection and the assigned volumes indicates that the primary reason for this level of service is the heavy volume of left-turning traffic from R3 to R18. The installation of traffic signals between now and 1982 (since these intersections have reached appropriate warrants) will permit on-airport intersections to provide an acceptable level of service for the peak hour on the design day in 1982.

EXHIBIT C-58

San Francisco International Airport

1982 DESIGN DAY PEAK HOUR

ON AIRPORT INTERSECTION CAPACITY ANALYSIS

Intersection	Level of Service
R-1 and R-16	A
R-1 and R-18	A
R-2 and R-16	A
R-3 and R-18	D
R-3 and R-6	B

- Off-airport intersections as in the prior case have been examined for the three peak hour periods. Exhibit C- 59 illustrates the results of this examination and shows that all intersections operate above design levels of service for each peak period. This review assumes completion of the highway/intersection improvements previously enumerated and the installation of traffic signals at the intersections of Millbrae Avenue and Old Bayshore Road and the South Airport Boulevard and North Access Road by the year 1982.

- Weaving capacity of main entrance road was examined in a manner similar to that described for the existing conditions review. The results of that analysis are presented in Exhibit C- 60 which shows two of the roadway segments operating at an overall roadway level of service C. The center segment operates at level of service D which means that weaving vehicles can maintain speeds of approximately 30-35 mph. Approach speeds on the upstream section will be 5 to 10 mph higher, therefore, occasional slowdowns and some restriction of maneuverability can

EXHIBIT C-59

San Francisco International Airport

1982 DESIGN DAY

OFF-AIRPORT INTERSECTION CAPACITY ANALYSIS

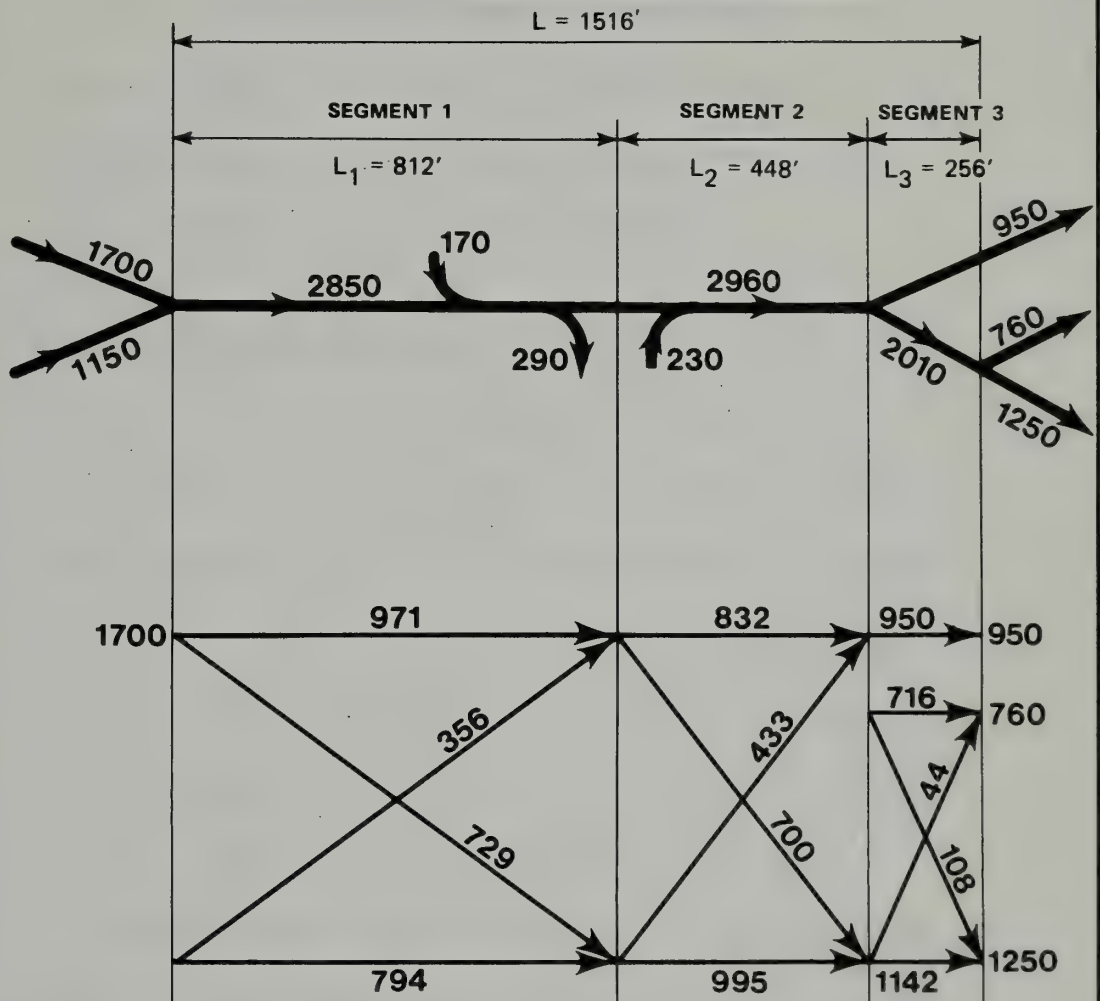
Intersection	Level of Service		
	3-4 P.M.	5-6 P.M.	7-8 P.M.
San Bruno Avenue & South Airport Blvd.	C	A	A
North Access Road & South Airport Blvd.	B	A	A
Millbrae Avenue & Old Bayshore Highway	A	A	A
El Camino Real & San Bruno Avenue	A	B	A
El Camino Real & Millbrae Avenue	C	B	A

EXHIBIT C–60

San Francisco International Airport

1982 DESIGN DAY PEAK HOUR

WEAVING SECTION ANALYSIS-MAIN ACCESS ROADWAY



WEAVING SECTION ANALYSIS

Total Roadway Volume (VPH)	2850	2960	2010
Total Weaving Volume (VPH)	1085	1133	152
For Roadway Level of Service	C	B	A
– Service Volume Per Lane (VPH)	1450	1250	800
– Required Number of Lanes	2.4	3.1	2.6
Existing Number of Lanes	3	4	3
Level Of Service Of Weaving Volume	C	D	C
Overall Roadway Level of Service	C	D	C

be expected in the center section. Segment 2 will, therefore, be the controlling factor for overall level of service and since this segment is more than 800 feet from the Bayshore interchange ramps, the overall level of service will be sufficient to avoid interference with main line volumes on the Bayshore Freeway.

- Public parking analysis for 1982 has been completed utilizing procedures identical to 1974 which places the 1982 design week at 262,200 enplanements and 268,600 deplanements (eliminating transfers). Air travel projections indicate that non-business travel will grow more rapidly than business travel and, therefore, result in changed "purpose" conditions for 1982 with 70% non-business and 30% business. Therefore, non-business enplanements/deplanements will be 183,500 and 188,000, respectively, with business enplanements/deplanements pegged at 78,700 and 80,600. Non-air passenger-related parking will require 2,510 long-term spaces and 6,090 short-term spaces. The result

of these trends is that the total number of parkers for the design week in 1982 will approximate 17,093 long-term and 135,890 short-term (see Exhibit C-61). Accumulation ratios convert these to peak parking requirements illustrated in Exhibit C-62 which shows a maximum accumulation of 6,722 vehicles on Friday at 7:00 P. M. One element of the improvement program has a significant effect on the parking supply/capacity relationship in 1982 - - the completion of the parking garage. If this improvement were not included, all garage and lot space in and around the airport would total 6,799 spaces. The projected peak accumulation of 6,722 would represent 99.2% occupancy. Since the practical capacity of public parking facilities cannot achieve more than 90% efficiency (6,100 spaces), a parking deficiency of approximately 600 spaces would exist in 1982 with no improvements. That number by itself does not appear excessive; however, it must be noted that operation under these conditions would require 55% of all

EXHIBIT C-61

San Francisco International Airport

1982 DESIGN CONDITIONS

AIRPORT PARKERS FOR TYPICAL WEEK IN AUGUST

	Long-Term Parking	Short-Term Parking
Business Enplanements	-	2,360
Non-Business Enplanements	-	49,555
Business Deplanements	12,327	12,086
Non-Business Deplanements	2,256	65,799
Subtotal	14,583	129,800
Non-Air Passenger-Related Parking	2,510	6,090
TOTAL	17,093	135,890

EXHIBIT C-62

San Francisco International Airport

1982 GARAGE ANALYSIS ACCUMULATION OF PARKED VEHICLES

	Long-Term	Short-Term	Total
Wednesday			
12:00 Noon	5,060	1,128	6,188
9:00 P.M.	3,778	1,332	5,110
Thursday			
12:00 Noon	4,820	1,128	5,948
9:00 P.M.	3,778	1,332	5,100
Friday			
12:00 Noon	4,273	1,332	5,605
7:00 P.M.	4,154	2,568	6,722
Saturday			
12:00 Noon	3,743	2,283	6,026

parking spaces to be served by shuttle bus operation. On the other hand, the improvement program as currently contemplated specifies expansion of the garage to 7,300 spaces (the 845 spaces in Lot 2 would be lost during construction resulting in a net increase of 3,455 spaces). Under these conditions, design day occupancy would represent 66.3% of available parking. With the 90% efficiency factor taken into consideration, the result is that a garage facility would handle all week day parking demands with the exception of the peak Friday accumulation when approximately 240 parkers would be required to use surface parking lots.

- Curb frontage analysis for 1982 was examined with and without construction of the north terminal. Under these two cases, passenger loadings in 1982 would be equalized between the central and south terminals at 50% each or allocated among the south, central and north terminals at one-third each. The consequences of not constructing the north terminal are evident from Exhibit C-63 and

EXHIBIT C-63

San Francisco International Airport

1982 CURB FRONTAGE ANALYSIS ENPLANING ROADWAY-WITHOUT EXPANSION

Type of Vehicle	Number of Vehicles	Average Air Passengers Per Vehicle	Deplaning Air Passengers Per Hour	Average( ) Foot Minutes Per Vehicle	Foot Minutes Required
Auto	1,077	1.1	1,185	50	53,850
Taxi	79	1.45	115	30	2,370
Hotel/Limo	175	6.0	1,050	105	18,375
Bus	10	32.0	320	110	1,100
	1,341		2,670		75,695

* * * *

Exhibit C- 64. Enplaning curb frontage for both terminals approximates 56.3% of possible capacity of curb frontage and falls within the limits of practical capacity. However, deplaning roadway curb frontage needs would not only exceed practical capacity by about 30% but would also exceed possible capacity with 149,575 foot minutes required against 149,040 foot minutes available. As a consequence under the "no build" option, deplaning roadway curb frontage will be subjected to illegal parking, double parking, excessive recirculation and long walking distances.

With completion of the north terminal, over 1,000 linear feet of curb frontage is added and the loads are split equally among the three terminal locations. The net effect of this is illustrated in Exhibit C- 65 and Exhibit C-66 which show all three enplaning curb faces operating at 34.4% of possible capacity and the deplaning frontage operating at 58.9% of possible capacity. In neither case does required curb frontage exceed the practical capacity.

EXHIBIT C-64

San Francisco International Airport

1982 CURB FRONTAGE ANALYSIS DEPLANING ROADWAY-WITHOUT EXPANSION

Type of Vehicle	Number of Vehicles	Average Air Passengers Per Vehicle	Deplaning Air Passengers Per Hour	Average Foot Minutes Per Vehicle	Foot Minutes Required
Auto	1,621	1.1	1,783	75	121,575
Taxi	142	1.9	270	50	7,100
Hotel/Limo	121	6.0	726	140	16,940
Bus	18	22.0	396	220	3,960
	1,902		3,175		149,575

* * * *

EXHIBIT C-65

San Francisco International Airport

1982 CURB FRONTAGE ANALYSIS ENPLANING ROADWAY-WITH EXPANSION

Type of Vehicle	Number of Vehicles	Average Air Passengers Per Vehicle	Deplaning Air Passengers Per Hour	Average Foot Minutes Per Vehicle	Foot Minutes Required
Auto	1,077	1.1	1,185	50	53,850
Taxi	79	1.45	115	30	2,370
Hotel/Limo	175	6.0	1,050	160	28,000
Bus	10	32.0	320	165	1,650
	1,341		2,670		85,870

* * * *

EXHIBIT C-66

San Fancisco International Airport

1982 CURB FRONTAGE ANALYSIS DEPLANING ROADWAY-WITH EXPANSION

Type of Vehicle	Number of Vehicles	Average Air Passengers Per Vehicle	Deplaning Air Passengers Per Hour	Average Foot Minutes Per Vehicle	Foot Minutes Required
Auto	1,621	1.1	1,738	75	121,575
Taxi	142	1.9	270	50	7,100
Hotel/Limo	121	6.0	726	210	25,410
Bus	18	22.0	396	330	5,940
	1,902		3,175		160,025

* * * *

- Off-airport highway capacity has been analyzed for each of the three peak hour periods assuming the highway improvements previous enumerated. Some improvements are evident in Exhibit C-67 over 1974 conditions as a result of these improvements. Substandard operation still exists in a few spots. The Bayshore Freeway south of the airport ramps operates at reasonable levels of service in "airport peak periods" but drops to level of service D northbound and E southbound in the 5 to 6 P. M. non-airport traffic peak. During this time period, only 25 % of this traffic is airport-related. Bayshore segments north of the airport ramps operate at acceptable levels of service during all time periods primarily because of the relief provided by the I-380 connections. Other off-airport sections operate at acceptable levels of service with the exception of the southbound ramp from the airport during the airport employee peak hour (3 to 4 P. M.) when it operates at level of service F indicating stop-and-go operation.

EXHIBIT C-67

San Francisco International Airport

1982 DESIGN DAY

OFF-AIRPORT HIGHWAY UTILIZATION

Facility/Location	Capacity (One-Way)	3-4 P.M. Volume	3-4 P.M. V/C	3-4 P.M. L of S	5-6 P.M. Volume	5-6 P.M. V/C	5-6 P.M. L of S	7-8 P.M. Volume	7-8 P.M. V/C	7-8 P.M. L of S
Freeway										
Bayshore Freeway										
So. of Airport Ramps (Northbound)	8,000	6,000	.75	C	7,200	.90	D	4,900	.61	B
So. of Airport Ramps (Southbound)	8,000	6,700	.84	D	7,800	.98	E	4,900	.61	B
No. of Airport Ramps (Northbound)	10,000	5,900	.59	B	7,000	.70	C	4,800	.48	B
No. of Airport Ramps (Southbound)	10,000	6,500	.65	C	7,600	.76	C	4,800	.48	B
Interchanges										
Bayshore Freeway										
Airport - SB-FR/Airport	1,800	2,000	1.10	F	1,310	.73	C	1,280	.71	C
SB-TO/Airport	3,200	1,300	.41	A	1,150	.36	A	1,700	.53	B
NB-FR/Airport	3,200	1,800	.56	B	1,270	.40	A	1,800	.56	B
NB-TO/Airport	1,800	1,500	.83	C	1,380	.77	C	1,150	.64	C
San Bruno Avenue - SB-FR/Airport	1,300	600	.46	B	400	.31	A	300	.23	A
SB-TO/Airport	1,300	200	.15	A	200	.15	A	100	.08	A
NB-FR/Airport	1,800	200	.11	A	150	.08	A	50	.03	A
NB-TO/Airport	1,800	250	.14	A	100	.06	A	50	.03	A
Millbrae Avenue - SB-FR/Airport	1,500	1,200	.80	D	800	.53	B	550	.31	A
SB-TO/Airport	500	250	.50	B	350	.70	C	150	.30	A
NB-FR/Airport	1,800	1,200	.67	C	1,100	.61	B	450	.25	A
NB-TO/Airport	1,800	650	.36	A	700	.39	A	350	.19	A

1990 Conditions

The assessment of impacts for 1990 at 31.0 million air passengers has been accomplished with and without planned airport expansion. However, an additional feature of this assessment is a review of the effect of the extension of rapid transit service from Daly City to the airport. Other highway improvements alluded to in the 1982 analysis are assumed to have been completed.

- On-airport intersections were reviewed through comparison of 1990 peak hour volumes with anticipated capacities. In this case, the critical peak period is the 3 to 4 P. M. employee peak and the results are illustrated in Exhibit C-68. It is evident from this chart that rapid transit has little or no effect on internal intersection operations. For both conditions, the intersection of R3 and R18 and the intersections of R3 and R6 are operating at less than acceptable levels of service.

- Off-airport intersections have been examined in similar fashion for each peak period.

EXHIBIT C-68

San Francisco International Airport

1990 DESIGN DAY PEAK HOUR

ON-AIRPORT INTERSECTION CAPACITY ANALYSIS

Intersection	Level of Service: 1990 Conditions Without Rapid Transit	Level of Service: 1990 Conditions With Rapid Transit
R-1 and R-16	B	B
R-1 and R-18	C	C
R-2 and R-16	B	A
R-3 and R-18	F	F
R-3 and R-6	E	D

Reasonable levels of service are anticipated in each case with two exceptions (Exhibit C-69) -- San Bruno and South Airport Boulevard intersection operates at level of service F in the 3 to 4 P. M. peak period regardless of rapid transit service and the El Camino Real-San Bruno Avenue intersection operates at level of service D in the 5 to 6 P. M. peak period. The former (level of service F) is primarily a function of the shift change for the United Airlines maintenance facility and the latter is primarily a function of the 90% of non-airport-related trips utilizing the intersection during the highway peak.

- Weaving capacity of main entrance road was likewise performed with and without rapid transit and in this case, there is some measurable effect. Results of the analysis without rapid transit are indicated in Exhibit C-70 which shows that the first segment between the Bayshore interchange and the ramps to and from R16 would operate at level of

EXHIBIT C-69

San Francisco International Airport

1990 DESIGN DAY

OFF-AIRPORT INTERSECTION CAPACITY ANALYSIS

Intersection	Level of Service					
	3-4 P.M.		5-6 P.M.		7-8 P.M.	
	Without Rapid Transit	With Rapid Transit	Without Rapid Transit	With Rapid Transit	Without Rapid Transit	With Rapid Transit
San Bruno Avenue & South Airport Blvd.	F	F	B	B	A	A
North Access Road & South Airport Blvd.	C	C	A	A	A	A
Millbrae Avenue & Old Bayshore Highway	A	A	A	A	A	A
El Camino Real & San Bruno Avenue	B	B	D	D	B	B
El Camino Real & Millbrae Avenue	B	B	A	A	A	A

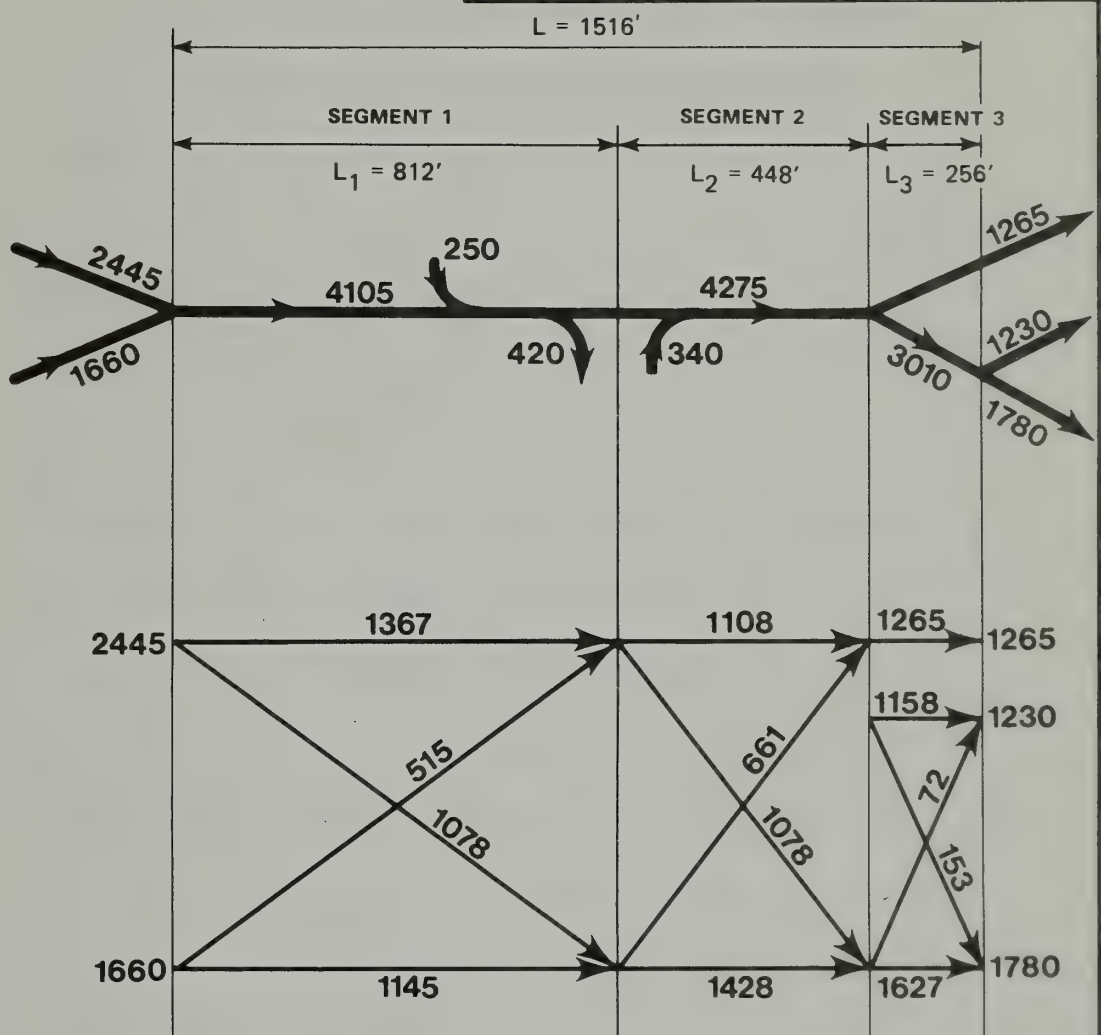
EXHIBIT C–70

San Francisco International Airport

1990 DESIGN DAY PEAK HOUR

WITHOUT RAPID TRANSIT

WEAVING SECTION ANALYSIS-MAIN ACCESS ROADWAY



WEAVING SECTION ANALYSIS

Total Roadway Volume (VPH)	4105	4275	3010
Total Weaving Volume (VPH)	1593	1739	225
For Roadway Level of Service	E	D	B
– Service Volume Per Lane (VPH)	2000	1650	1167
– Required Number of Lanes	2.6	3.4	2.7
Existing Number of Lanes	3	4	3
Level Of Service Of Weaving Volume	D	D	B
Overall Roadway Level of Service	E	D	B

service E. This indicates speeds generally below 30 mph and frequently below 20 mph. The second and third segments would operate at overall levels of service D and B, respectively. However, the first segment would effectively control operations of the total roadway and due to the low speeds and somewhat unstable operating characteristics associated with level of service E, it is likely that occasional delays to main line traffic on the Bayshore Freeway will occur when the storage capacity of the ramps is exceeded. If the rapid transit extension is incorporated into this analysis, the results would change to those illustrated in Exhibit C-71. Segment 1 weaving volume is reduced from 1,593 vehicles to 1,421 vehicles with total roadway volume of 3,755 vehicles resulting in an overall roadway level of service D. Once again, Segment 1 is the controlling factor for operations of the roadway and with level of service D, operating speeds of 30-35 mph can be anticipated with occasional slowdowns

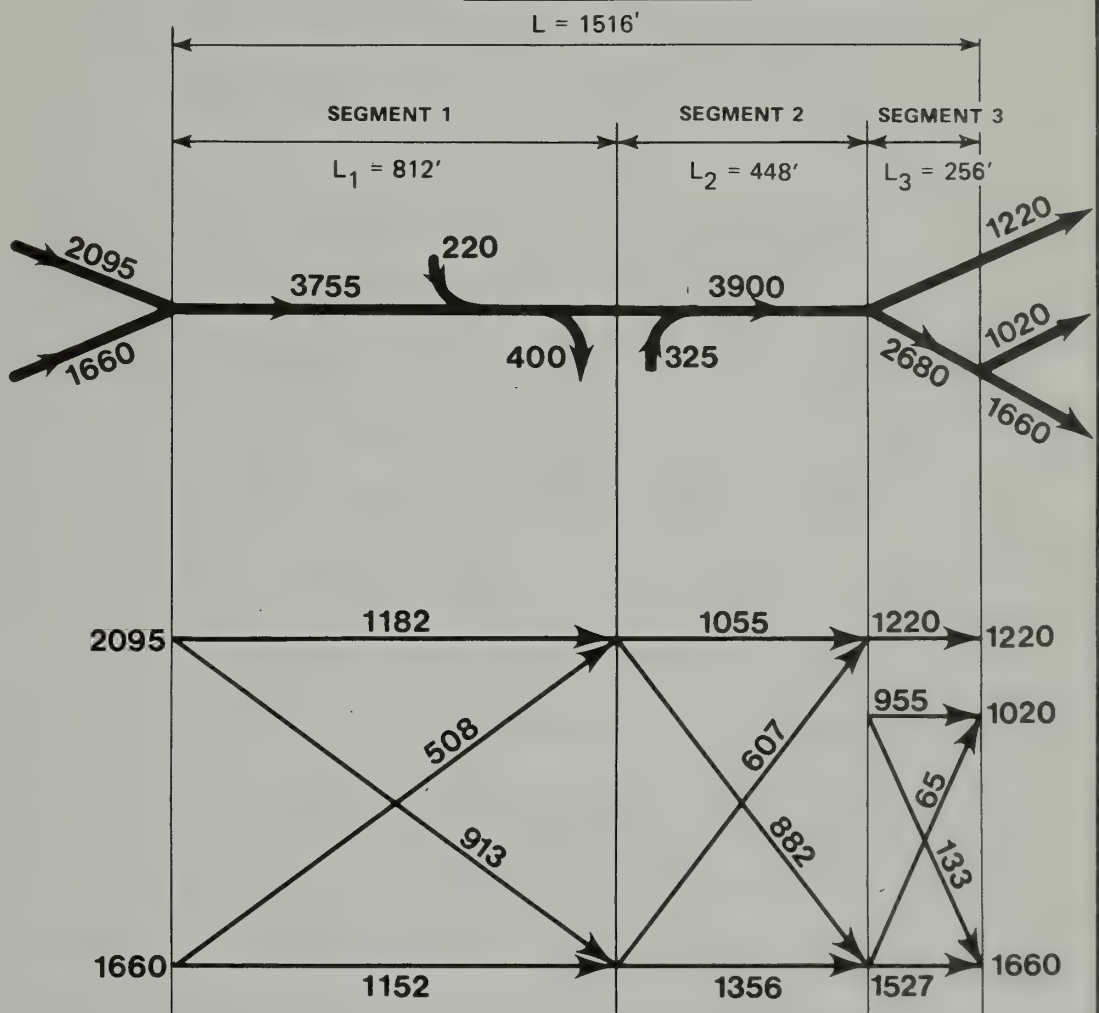
EXHIBIT C–71

San Francisco International Airport

1990 DESIGN DAY PEAK HOUR

WITH RAPID TRANSIT

WEAVING SECTION ANALYSIS-MAIN ACCESS ROADWAY



WEAVING SECTION ANALYSIS

Total Roadway Volume (VPH)	3755	3900	2680
Total Weaving Volume (VPH)	1421	1489	198
For Roadway Level of Service	D	C	B
– Service Volume Per Lane (VPH)	1633	1500	1167
– Required Number of Lanes	2.9	3.4	2.4
Existing Number of Lanes	3	4	3
Level Of Service Of Weaving Volume	C	D	A
Overall Roadway Level of Service	D	D	B

and some restrictions of maneuverability. However, this level of service will be sufficient to avoid interference with the main line volumes on the Bayshore Freeway.

- Public parking analysis for this condition parallels the prior analyses with typical week enplanements and deplanements, adjusted for transfers, represented by 333,100 enplanements and 341,200 deplanements. Non-business enplanements/deplanements will be 233,200 and 238,800, respectively, with business enplanements at 100,000 and deplanements at 102,400. Non-air passenger-related parking will require 2,640 long-term spaces and 7,540 short-term spaces. Converting these movements to parking demand results in Exhibit C-72 which shows a total demand of 21,168 long-term parkers and 172,447 short-term parkers. The conversion to peak accumulation is accomplished in Exhibit C- 73which develops a peak Friday evening accumulation of 8,403 spaces. This peak accumulation must be examined under four

EXHIBIT C-72

San Francisco International Airport

1990 DESIGN CONDITIONS

AIRPORT PARKERS FOR TYPICAL WEEK IN AUGUST

	Long-Term Parking	Short-Term Parking
Business Enplanements	-	2,998
Non-Business Enplanements	-	62,959
Business Deplanements	15,662	15,354
Non-Business Deplanements	2,866	83,596
Subtotal	18,528	164,907
Non-Air-Passenger-Related Parking	2,640	7,540
TOTAL	21,168	172,447

EXHIBIT C-73

San Francisco International Airport

1990 GARAGE ANALYSIS ACCUMULATION OF PARKED VEHICLES-WITHOUT RAPID TRANSIT

	Long-Term	Short-Term	Total
Wednesday			
12:00 Noon	6,266	1,431	7,697
9:00 P.M.	4,678	1,690	6,368
Thursday			
12:00 Noon	5,969	1,431	7,400
9:00 P.M.	4,678	1,690	6,368
Friday			
12:00 Noon	5,292	1,690	6,982
7:00 P.M.	5,144	3,259	8,403
Saturday			
12:00 Noon	4,636	2,897	7,533

options - - with and without airport improvements and with and without rapid transit. The basic set of numbers developed thus far in this paragraph relate to conclusions without rapid transit.

If airport improvements are not constructed, the peak parking accumulation of 8,403 would represent a 24% overrun of the existing 6,779 parking spaces. Incorporating the 90% efficiency factor would leave an actual parking deficiency of 2,300 spaces in 1990. On the other hand, if the expansion program moves ahead as planned, the peak parking accumulation of 8,403 space needs would represent approximately 83% occupancy of 1990 parking spaces. Supply is adequate, taking account of the 90% efficiency factor.

The effect of rapid transit on these two conditions is to lower the peak accumulation demand from 8,403 to 7600 . The respective conclusions remain the same - - the "no build" option is

short by 1500 parking spaces and the airport improvement program would provide sufficient parking.

- Curb frontage needs parallels the basic assumptions delineated for the 1982 review with and without expansion. The results of the "no build" option is illustrated in Exhibit C-74 and Exhibit C- 75. Taking account of practical capacity of the curb frontages, both the enplaning and deplaning roadways show demands exceeding the practical capacity of available curb frontage. Once again, the deplaning roadway is more critical than the enplaning roadway with the required capacity almost double the available practical capacity.

  Completion of the north terminal and reallocation of curb space and demand results in the analysis indicated in Exhibits C- 76 and C- 77. The enplaning roadway at all three terminal spots shows required curb frontage well within practical capacity with required frontage of

EXHIBIT C-74

San Francisco International Airport

1990 CURB FRONTAGE ANALYSIS ENPLANING ROADWAY-WITHOUT EXPANSION

Type of Vehicle	Number of Vehicles	Average Air Passengers Per Vehicle	Deplaning Air Passengers Per Hour	Average( ) Foot Minutes Per Vehicle	Foot Minutes Required
Auto	1,368	1.1	1,505	50	68,400
Taxi	100	1.45	145	30	3,000
Hotel/Limo	226	6.0	1,356	105	23,730
Bus	10	32.0	320	110	1,100
	1,704		3,326		96,230

* * * *

EXHIBIT C-75

San Francisco International Airport

1990 CURB FRONTAGE ANALYSIS DEPLANING ROADWAY-WITHOUT EXPANSION

Type of Vehicle	Number of Vehicles	Average Air Passengers Per Vehicle	Deplaning Air Passengers Per Hour	Average( ) Foot Minutes Per Vehicle	Foot Minutes Required
Auto	2,060	1.1	2,266	75	154,500
Taxi	180	1.9	342	50	9,000
Hotel/Limo	156	6.0	936	140	21,840
Bus	25	22.0	550	220	5,500
	2,421		4,094		190,840

* * * *

EXHIBIT C-76

San Francisco International Airport

1990 CURB FRONTAGE ANALYSIS ENPLANING ROADWAY-WITH EXPANSION

Type of Vehicle	Number of Vehicles	Average Air Passengers Per Vehicle	Deplaning Air Passengers Per Hour	Average( ) Foot Minutes Per Vehicle	Foot Minutes Required
Auto	1,368	1.1	1,505	50	68,400
Taxi	100	1.45	145	30	3,000
Hotel/Limo	226	6.0	1,356	160	36,160
Bus	10	32.0	320	165	1,650
	1,704		3,326		109,210

* * * \

EXHIBIT C-77

San Francisco International Airport

1990 CURB FRONTAGE ANALYSIS DEPLANING ROADWAY-WITH EXPANSION

Type of Vehicle	Number of Vehicles	Average Air Passengers Per Vehicle	Deplaning Air Passengers Per Hour	Average( ) Foot Minutes Per Vehicle	Foot Minutes Required
Auto	2,060	1.1	2,266	75	154,500
Taxi	180	1.9	342	50	9,000
Hotel/Limo	156	6.0	936	210	32,760
Bus	25	22.0	550	330	8,250
	2,421		4,094		204,510

* * * *

109,210 foot minutes and a practical capacity of 174,720. The deplaning roadway shows a curb frontage demand of 75% of possible capacity with a requirement only about 5% above practical capacity (204,510 foot minutes required vs. 190,260 foot minutes practical capacity). The inclusion of rapid transit in this analysis shows split reductions in curb frontage requirements as calculated in Exhibits C- 78 and C-79. The enplaning roadway demand is well within practical capacity and the deplaning roadway is only 1% above the optimum design criteria set for practical capacity.

- Off-airport highway capacity - The 1990 analysis has been completed with and without rapid transit extension. Without rapid transit, both directions of the Bayshore Freeway south of the airport interchange will operate at level of service B in the 3 to 4 P. M. airport employee peak hour and levels of service E northbound and F southbound in the 5 to 6 P. M. general

EXHIBIT -78

San Francisco International Airport

1990 CURB FRONTAGE ANALYSIS ENPLANING ROADWAY-WITH EXPANSION AND RAPID TRANSIT

Type of Vehicle	Number of Vehicles	Average Air Passengers Per Vehicle	Deplaning Air Passengers Per Hour	Average( ) Foot Minutes Per Vehicle	Foot Minutes Required
Auto	1,723	1.1	1,400	50	63,650
Taxi	70	1.45	101	30	2,100
Hotel/Limo	221	6.0	1,326	160	35,360
Bus	6	32.0	192	165	990
	1,570		3,019		102,100

* * * *

EXHIBIT C-79

San Francisco International Airport

1990 CURB FRONTAGE ANALYSIS DEPLANING ROADWAY-WITH EXPANSION AND RAPID TRANSIT

Type of Vehicle	Number of Vehicles	Average Air Passengers Per Vehicle	Deplaning Air Passengers Per Hour	Average( ) Foot Minutes Per Vehicle	Foot Minutes Required
Auto	1,985	1.1	2,183	75	148,875
Taxi	135	1.9	256	50	6,750
Hotel/Limo	154	6.0	924	210	32,340
Bus	14	22.0	308	330	4,620
	2,288		3,671		192,585

* * * *

traffic peak (Exhibit C-80). During the critical 5-6 P.M. hour, airport-related traffic varies from 30% to 33% of all traffic on the freeway. During air passenger peaks, all links of the freeway operate at reasonable levels of service. The southbound ramp from the airport to the Bayshore Freeway operates at level of service F during all three critical hours. The northbound ramp to the airport likewise operates under forced flow conditions at level of service F with the exception of the 7 to 8 P. M. air passenger peak.

If rapid transit is extended to the airport, a few off-airport sites will be affected, principally the Bayshore Freeway north and southbound of the airport where the level of service in the 5 to 6 P. M. timeframe is improved from D without rapid transit to an acceptable design value of C with rapid transit (Exhibit C-81). Two other significant improvements are evident wherein the northbound ramp from the airport improves from level of service D to C in both the 3 to

EXHIBIT C-80

San Francisco International Airport

1990 DESIGN DAY WITHOUT RAPID TRANSIT

OFF-AIRPORT HIGHWAY UTILIZATION

Facility/Location	Capacity (One-Way)	3-4 P.M. Volume	V/C	L of S	5-6 P.M. Volume	V/C	L of S	7-8 P.M. Volume	V/C	L of S
Freeway										
Bayshore Freeway										
So. of Airport Ramps (Northbound)	8,000	6,700	0.84	D	8,000	1.00	E	5,300	0.66	C
So. of Airport Ramps (Southbound)	8,000	7,100	0.89	D	8,300	1.04	F	5,300	0.66	C
No. of Airport Ramps (Northbound)	10,000	6,800	0.68	C	8,100	0.81	D	5,500	0.55	B
No. of Airport Ramps (Southbound)	10,000	7,600	0.76	C	8,800	0.88	D	5,500	0.55	B
Interchanges										
Bayshore Freeway										
Airport - SB-FR/Airport	1,800	3,000	1.67	F	1,970	1.09	F	1,910	1.06	F
SB-TO/Airport	3,200	2,000	0.63	B	1,770	0.55	B	2,445	0.76	C
NB-FR/Airport	3,200	2,700	0.84	D	1,900	0.59	B	2,700	0.84	D
NB-TO/Airport	1,800	2,100	1.17	F	1,930	1.07	F	1,660	0.92	E
San Bruno Avenue - SB-FR/Airport	1,300	750	0.58	B	500	0.39	A	350	0.27	A
SB-TO/Airport	1,300	250	0.19	A	250	0.19	A	150	0.16	A
NB-FR/Airport	1,800	250	0.14	A	200	0.11	A	100	0.06	A
NB-TO/Airport	1,800	300	0.17	A	150	0.08	A	50	0.03	A
Millbrae Avenue - SB-FR/Airport	1,500	1,300	0.87	D	850	0.57	B	600	0.40	A
SB-TO/Airport	500	300	0.60	B	400	0.80	C	200	0.40	A
NB-FR/Airport	1,800	1,300	0.72	C	1,200	0.67	C	500	0.28	A
NB-TO/Airport	1,800	700	0.39	A	800	0.44	B	350	0.19	A

EXHIBIT C-81

San Francisco International Airport

1990 DESIGN DAY WITH RAPID TRANSIT

OFF-AIRPORT HIGHWAY UTILIZATION

Facility/Location	Capacity (One-Way)	3-4 P.M. Volume	3-4 P.M. V/C	3-4 P.M. L of S	5-6 P.M. Volume	5-6 P.M. V/C	5-6 P.M. L of S	7-8 P.M. Volume	7-8 P.M. V/C	7-8 P.M. L of S
Freeway										
Bayshore Freeway										
So. of Airport Ramps (Northbound)	8,000				1/					
So. of Airport Ramps (Southbound)	8,000				1/					
No. of Airport Ramps (Northbound)	10,000	6,500	.65	C	7,700	.77	C	5,300	.53	B
No. of Airport Ramps (Southbound)	10,000	7,100	.71	C	8,300	.83	C	5,300	.53	B
Interchanges										
Bayshore Freeway										
Airport - SB-FR/Airport	1,800				1/					
SB-TO/Airport	3,200	1,700	.53	B	1,510	.47	B	2,095	.66	C
NB-FR/Airport	3,200	2,200	.69	C	1,550	.48	B	2,200	.69	C
NB-TO/Airport	1,800				1/					
San Bruno Avenue - SB-FR/Airport	1,300									
SB-TO/Airport	1,300				1/					
NB-FR/Airport	1,800									
NB-TO/Airport	1,800									
Millbrae Avenue - SB-FR/Airport	1,500									
SB-TO/Airport	500				1/					
NB-FR/Airport	1,800									
NB-TO/Airport	1,800									

1/ These ramps are not affected by rapid transit extension to San Francisco International Airport

4 P. M. and 7 to 8 P. M. periods. In all other cases, the improvement is not sufficient to make a change in level of service.

8. MITIGATING MEASURES

An evaluation of alternative highway improvements was undertaken to determine possible mitigating measures required to improve the overall levels of service in the three analysis areas of on-airport intersections, off-airport intersections and off-airport highway utilization.

- On-airport intersections - The impact assessments completed under the passenger loadings of 24.4 million air passengers (1982) and 31.0 million air passengers (1990) have assumed the signalization of the intersections of R1 and R18, R3 and R18 and R3 and R6, as well as the widening of R3 to four lanes with a separate left-turn lane at its intersection with R6.

  - Recommended Improvement - Under the highest traffic loading occurring in 1990, the only intersection operating over capacity (by 400 vehicles) is the intersection of R3 and R18.

The primary reason for the operational breakdown at this intersection is the extremely high volume (over 1,000 vehicles in 1990) of left-turning vehicles from R3 to R18. The construction of a two-lane jughandle for this movement (through the existing parking lot and opposite the R18 approach) would enable the operation of the intersection to improve to level of service A in 1982 (previously D), and level of service D in 1990 (previously F).

- Off-airport intersections - The future impact assessments have assumed the completion of I-380, linking the Bayshore Freeway with the Junipero Serra Freeway (I-280), the reconstruction and expansion of the Bayshore Freeway from the airport interchange north to the I-380 interchange, as well as the widening of Old Bayshore Road to allow for a double left-turn lane at its intersection with Millbrae Avenue.

  - Recommended Improvement - The redistribution of traffic through the intersection of San

Bruno Avenue and South Airport Boulevard in 1990 shows an operating level of service F (over capacity). The reconstruction of San Bruno Avenue to provide for separate left-turn lanes at the intersection will improve the overall level of service to level B (stable flow) in 1990.

- Off-airport highway utilization - The analysis of the off-airport utilization has assumed the network improvements previously stated and the widening of two airport interchange ramps from one to two lanes (southbound ramp to airport and northbound ramp from airport).

  - Recommended Improvement - The southbound airport interchange ramp from the airport will operate over capacity during the 3 to 4 P. M. peak hour in 1982 and over capacity for all three analysis hours in 1990. The widening of this ramp from one to two lanes will increase the level of service during the highest hourly volume to level B in 1982 and level D in 1990.

The northbound airport interchange ramp to the airport will operate over capacity during the 3 to 4 P. M. and 5 to 6 P. M. peaks and at capacity during the 7 to 8 P. M. peak. The widening of this ramp from one to two lanes will increase the level of service to level B for all three analysis hours in 1990.

9. SUMMARY AND CONCLUSIONS

Detailed analysis of the adequacy of the ground access facilities of the San Francisco International Airport and the highway system immediately adjacent to the airport have been completed for 1974, 1982 (with and without the planned airport expansion program), 1990 (with and without the planned airport expansion program) and 1990 (with the planned airport expansion and the proposed rapid transit extension to the airport). A brief review of the findings of these impact assessments is presented for the following areas.

- On-airport intersections - Exhibit C-82 presents a comparison of the operating levels of service of the five on-airport intersections.

EXHIBIT C-82

San Francisco International Airport

SUMMARY OF ON-AIRPORT INTERSECTION

LEVEL OF SERVICE FOR ALTERNATIVE CONDITIONS

	Level Of Service			
Intersection	1974	1982	1990 Without Rapid Transit	1990 With Rapid Transit
R-1 and R-16	A	A	B	B
R-1 and R-18	A	A	C	C
R-2 and R-16	A	A	B	A
R-3 and R-18	C	D	F	F
R-3 and R-6	A	B	E	D

This overall analysis has revealed that the on-airport intersections will provide an acceptable level of service under the traffic demands of the 24.4 and 31.0 million air passenger years with the exception of the intersection of R3 and R18. The implementation of the mitigating measures recommended for this intersection will result, however, in significantly higher levels of service. Although the provision of a rapid transit extension would result in higher levels of service at two of the five intersections, the overall impact on the traffic demands for the on-airport intersections and roadways is relatively insignificant.

- Off-airport intersections - A summary of the operating levels of service for the five off-airport intersections is shown in Exhibit C-83. Once again, the overall impact analysis has revealed that the off-airport intersections will provide an acceptable level of service during the 24.4 and 31.0 million air passenger years with the exception of the intersection of San

EXHIBIT C-83

San Francisco International Airport

SUMMARY OF DESIGN DAY

OFF-AIRPORT INTERSECTION CAPACITY ANALYSIS

Intersection	Level Of Service								
	3-4 P.M.			5-6 P.M.			7-8 P.M.		
	1974	1982	1990[1]/	1974	1982	1990	1974	1982	1990
San Bruno Avenue & South Airport Blvd.	C	C	F	A	A	B	A	A	A
North Access Road & South Airport Blvd.	A	B	C	A	A	A	A	A	A
Millbrae Avenue & Old Bayshore Highway	A	A	A	A	A	A	A	A	A
El Camino Real & San Bruno Avenue	C	A	B	E	B	D	A	A	B
El Camino Real & Millbrae Avenue	B	C	B	E	B	D	A	A	B

1/ Rapid transit effect insufficient to change level of service.

Bruno Avenue and South Airport Boulevard. However, the implementation of the mitigating measures recommended for the intersection will result in a significantly higher level of service. The provision of rapid transit will have no measurable impact on the operating levels of service of the off-airport intersections in 1990. The completion of I-380 and the other highway improvements will result, however, in higher levels of service under 1982 conditions than the existing conditions at a number of the intersections.

- Main access roadway weaving section - Exhibit C- 84 presents the overall levels of service for the three critical segments of the main access roadway weaving section. The main access roadway will operate at a lower overall highway speed (5-10 mph) in the 1982 design day due to the increased air passenger traffic. Since Segment 2 controls the overall operation and is sufficiently removed (800 feet) from the airport interchange, no interference with the

EXHIBIT C-84

San Francisco International Airport

SUMMARY OF WEAVING SECTION ANALYSIS

SOUTH RAMPS - MAIN ROADWAY

DESIGN DAY - PEAK HOUR

Conditions	Overall Roadway Level of Service		
	Segment 1	Segment 2	Segment 3
1974	C	C	A
1982	C	D	C
1990 Without Rapid Transit	E	D	B
1990 With Rapid Transit	D	D	B

airport interchange ramps should occur. For the design day in 1990, the main access roadway will operate at capacity with speeds normally below 30 mph and frequently averaging 20 mph or less. The potential of interference with the through traffic on the Bayshore Freeway is extremely high if a traffic accident or other unusual slowdown occurs on the main access roadway. The provision of rapid transit shows an improvement in the main access roadway's overall operating speeds (5-10 mph) over the 1990 conditions without rapid transit. The operating characteristics of the roadway with rapid transit will be similar to those encountered in 1982.

- Public parking facilities - The projected peak parking accumulation for 1982 and 1990 is 6,779 and 8,403 spaces, respectively. As such, an evaluation of the future public parking supply/demand relationships reveals a projected deficiency of 600 spaces in 1982 and 2,300 spaces in 1990 (under the alternative of no improvements to the public parking supply).

The provision of 10,134 spaces in 1990 (7,300 garage spaces) would represent 83% occupancy during the peak parking accumulation of the design week. Exhibit C-85 presents the results of the analysis.

- Curb frontage - A practical capacity of 70% has been determined as the desired level of usage for curb frontage. Without the provision of the north terminal curb space, the enplaning roadway would continue to function below capacity in 1982 and 1990. The deplaning roadway, however, would exceed capacity in both 1982 (100% usage) and 1990 (128% usage). The allowance for the north terminal curb frontage and the curb frontage adjacent to the two plaza areas between the three terminals (with expansion conditions), would lower the usage on the deplaning roadway to 56% in 1982 and 75% in 1990. The provision of rapid transit would lower the required usage on the deplaning roadway to 41% and 71%, respectively. Exhibit C-86 presents the results of the analysis.

EXHIBIT C-85

San Francisco International Airport

ANALYSIS OF PUBLIC PARKING FACILITIES

	Peak Design Day Accumulation	Spaces Available	% Filled
1974	4,986	6,779	73.6%
1982			
- Without Improvement	6,722	6,779	99.2%
- With Improvement	6,722	10,134	66.3%
1990			
- Without Improvement	8,403	6,779	124.0%
- With Improvement	8,403	10,134	82.9%

EXHIBIT C-86

San Francisco International Airport

SUMMARY OF CURB FRONTAGE ANALYSIS

	Available Ft. Min.	Required Ft. Min.	Percent Used
1974 Design Day, Peak Hour			
Central Terminal			
Deplaning Roadway	74,400	61,534	82.7%
Enplaning Roadway	68,160	32,292	47.4%
South Terminal			
Deplaning Roadway	74,640	41,081	55.0%
Enplaning Roadway	66,240	21,538	32.5%
1982 Design Day, Peak Hour (Without Expansion)			
Two Terminals			
Deplaning Roadway	149,040	149,575	100.4%
Enplaning Roadway	134,400	75,695	56.3%
1982 Design Day, Peak Hour (With Expansion)			
Three Terminals			
Deplaning Roadway	271,800	160,025	58.9%
Enplaning Roadway	249,600	85,870	34.4%
1990 Design Day, Peak Hour (Without Expansion)			
Two Terminals			
Deplaning Roadway	149,040	190,840	128.0%
Enplaning Roadway	134,400	96,230	71.6%
1990 Design Day, Peak Hour (With Expansion)			
Three Terminals			
Deplaning Roadway	271,800	204,510	75.2%
Enplaning Roadway	249,600	109,210	43.8%
1990 Design Day, Peak Hour (With Expansion) and Rapid Transit Extension to San Francisco International Airport			
Three Terminals			
Deplaning Roadway	271,800	192,585	70.8%
Enplaning Roadway	249,600	102,100	40.9%

- Off-airport highway utilization - Exhibit C-87 presents the results of the off-airport highway utilization analysis of the Bayshore Freeway and its interchanges with the airport, San Bruno Avenue, and Millbrae Avenue. Due to the completion of I-380 and the reconstruction and expansion of the Bayshore Freeway north to the I-380 interchange, the analysis has revealed that the main line section of the Bayshore Freeway (north of the airport interchange), its interchanges with San Bruno Avenue and Millbrae Avenue, and the airport ramps to and from the airport from the north will provide acceptable levels of service in both 1982 and 1990. The airport ramps to and from the airport from the south will operate at or over capacity during the critical hours of the analysis. However, the implementation of the mitigating measures recommended for those ramps (widening from one to two lanes) will also result in acceptable levels of service in 1982 and 1990. The main line section of the Bayshore Freeway (south of the airport interchange) will operate

EXHIBIT C-87

San Francisco International Airport

SUMMARY OF DESIGN DAY

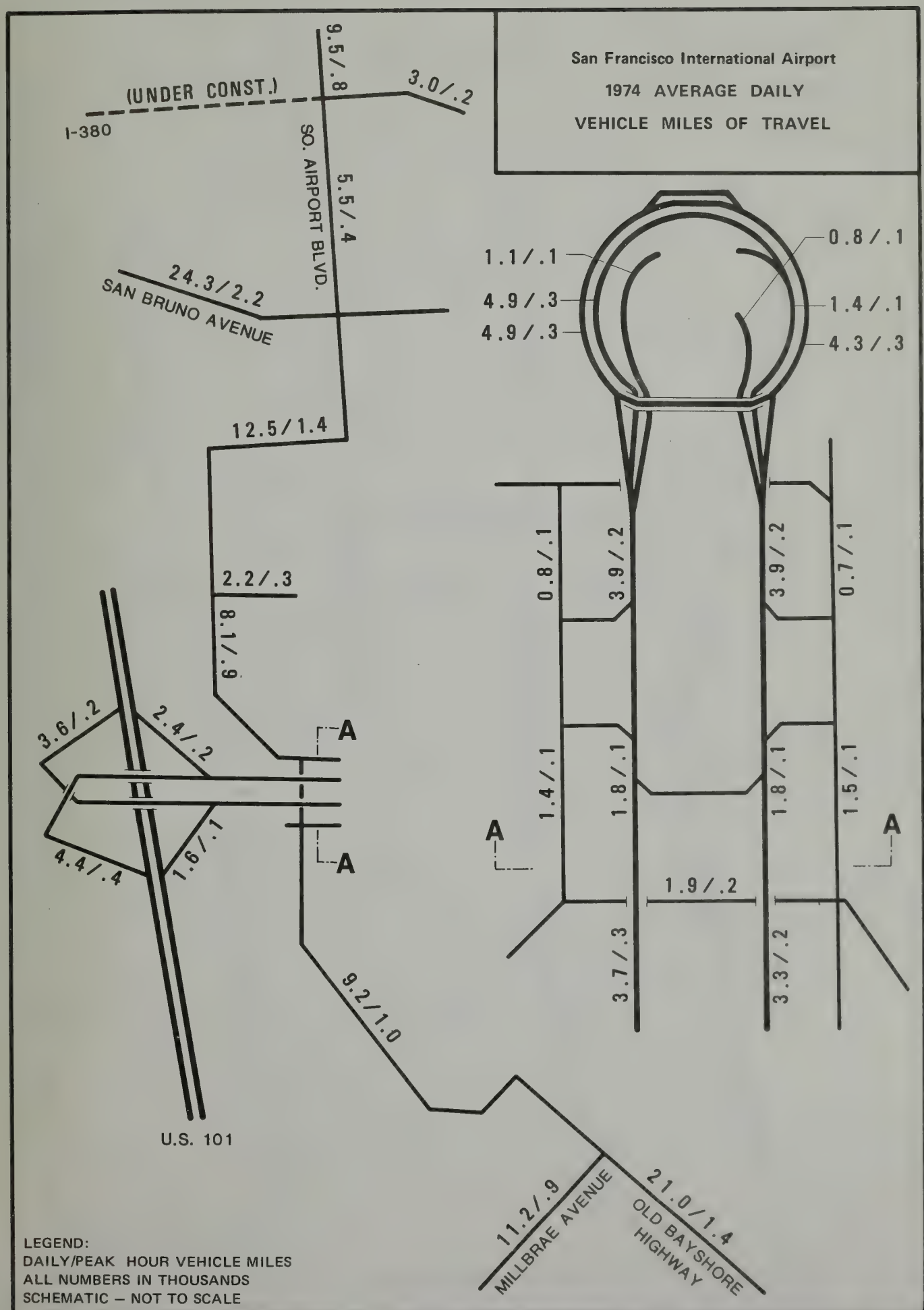
OFF-AIRPORT HIGHWAY UTILIZATION

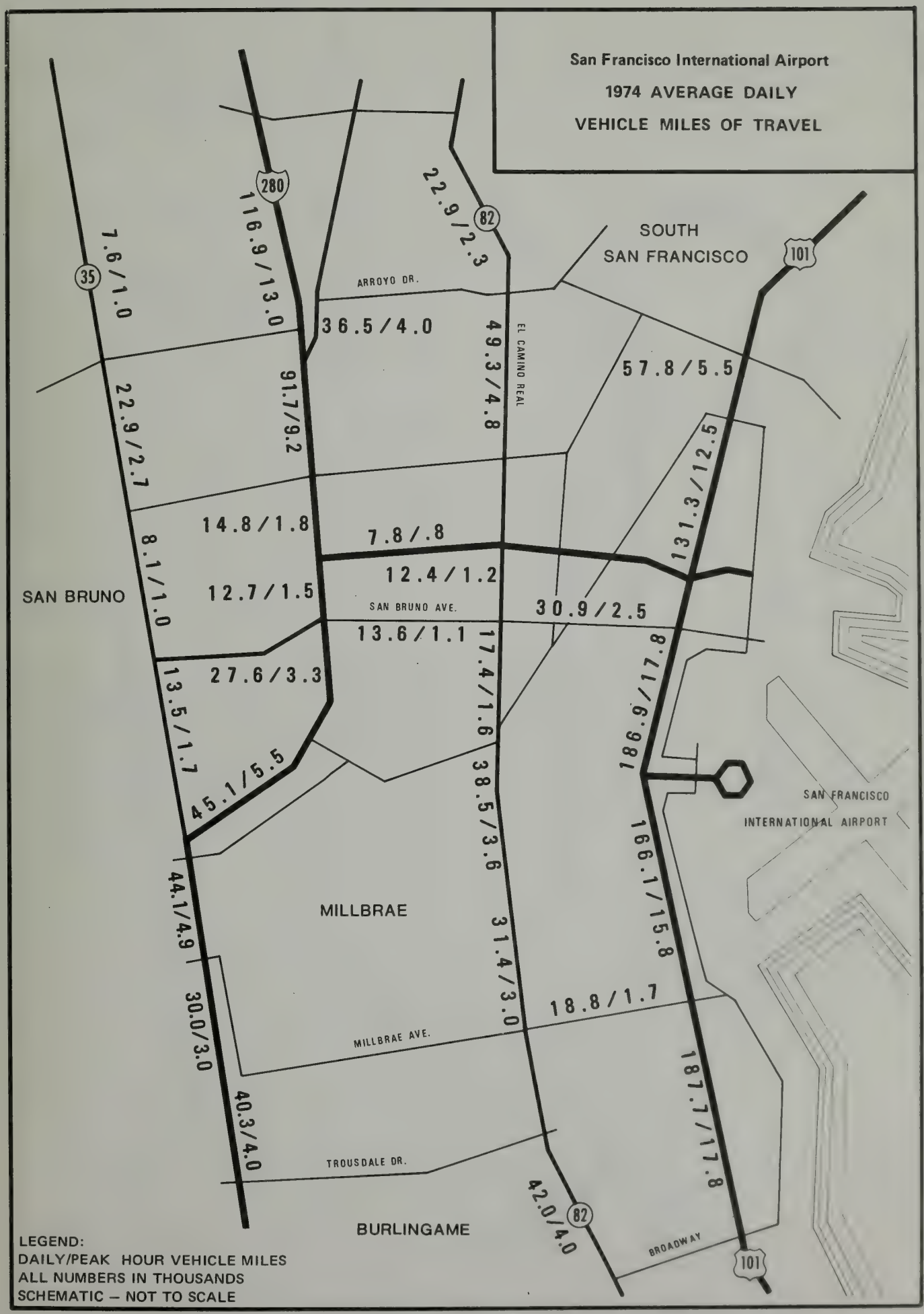
Facility/Location	Level Of Service											
	3-4 P.M.				5-6 P.M.				7-8 P.M.			
	1974	1982	1990 Without Rapid Transit	1990 With Rapid Transit	1974	1982	1990 Without Rapid Transit	1990 With Rapid Transit	1974	1982	1990 Without Rapid Transit	1990 With Rapid Transit
Freeway												
Bayshore Freeway												
So. of Airport Ramps (Northbound)	C	C	D	-	D	D	E	-	B	B	C	-
So. of Airport Ramps (Southbound)	C	D	D	-	D	E	F	-	B	B	C	-
No. of Airport Ramps (Northbound)	C	B	C	C	D	C	D	C	B	B	B	B
No. of Airport Ramps (Southbound)	C	C	C	C	E	C	D	C	B	B	B	B
Interchanges												
Bayshore Freeway												
Airport - SB-FR/Airport	C	F	F	-	B	C	F	-	B	C	F	-
SB-TO/Airport	B	A	B	B	B	A	B	B	B	B	C	C
NB-FR/Airport	C	B	D	C	B	A	B	B	C	B	D	C
NB-TO/Airport	B	C	F	-	B	C	F	-	A	C	E	-
San Bruno Avenue - SB-FR/Airport	C	B	B	-	B	A	A	-	A	A	A	-
SB-TO/Airport	A	A	A	-	A	A	A	-	A	A	A	-
NB-FR/Airport	A	A	A	-	A	A	A	-	A	A	A	-
NB-TO/Airport	A	A	A	-	A	A	A	-	A	A	A	-
Millbrae Avenue - SB-FR/Airport	B	D	D	-	A	B	B	-	A	A	A	-
SB-TO/Airport	A	B	B	-	B	C	C	-	A	A	A	-
NB-FR/Airport	B	C	C	-	B	B	C	-	A	A	A	-
NB-TO/Airport	A	A	A	-	A	A	B	-	A	A	A	-

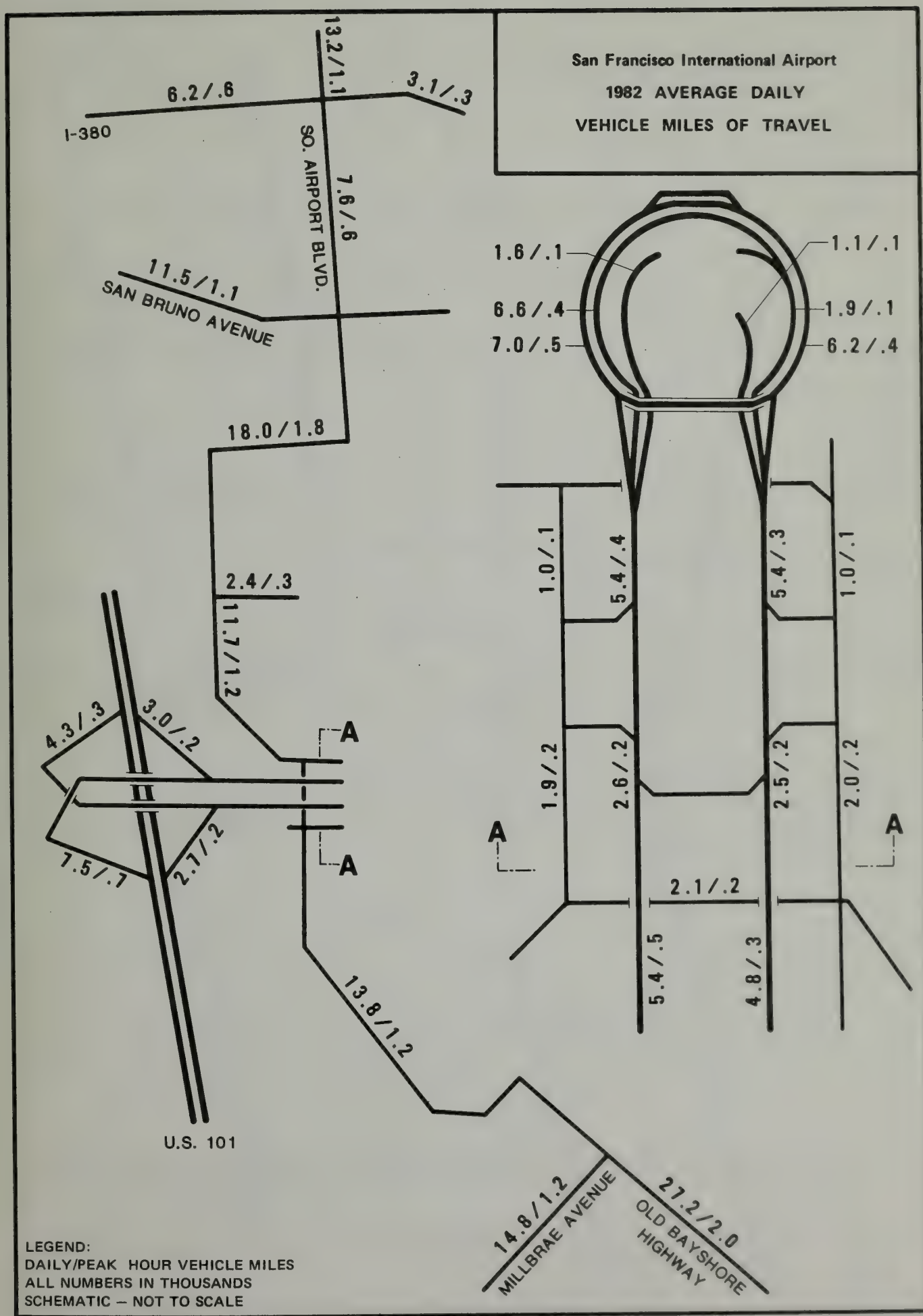
at level of service E or better during the 1982 analysis hours and over capacity during the normal highway peak hour in 1990. Once again, the provision of rapid transit results in a slight improvement to the overall off-airport highway utilization.

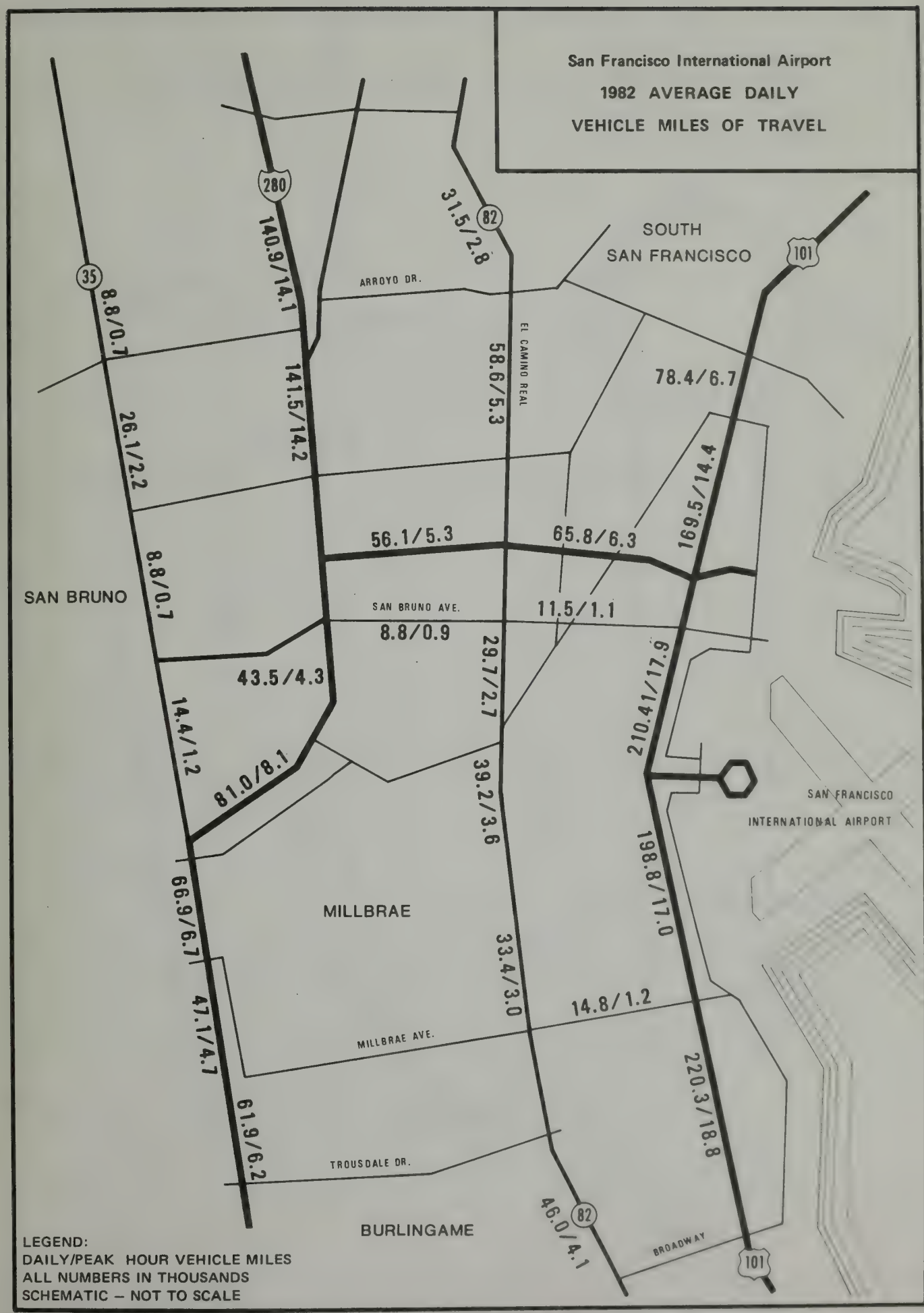
VEHICLE MILES OF TRAVEL ESTIMATES

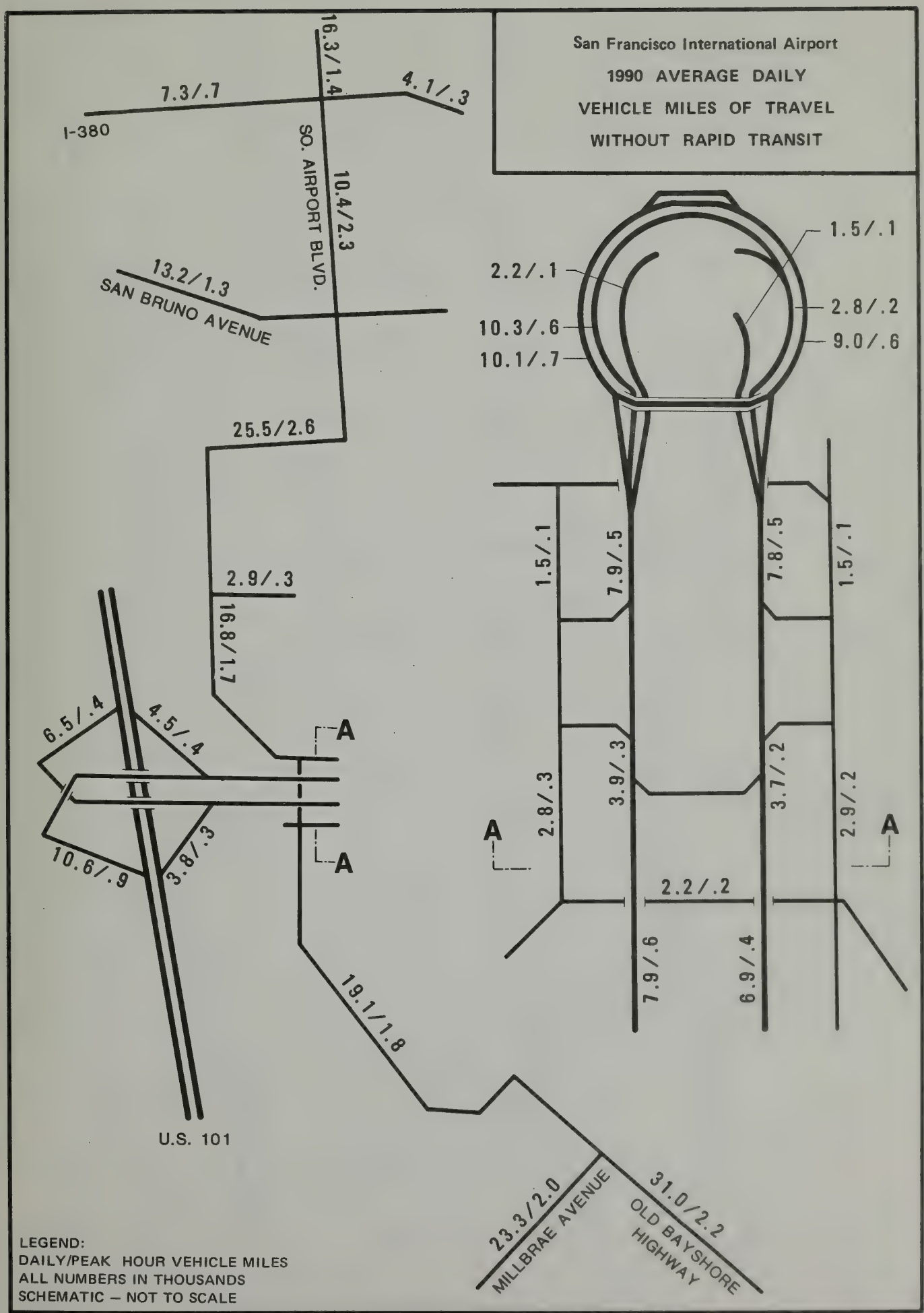
PREPARED FOR AIR QUALITY ANALYSIS

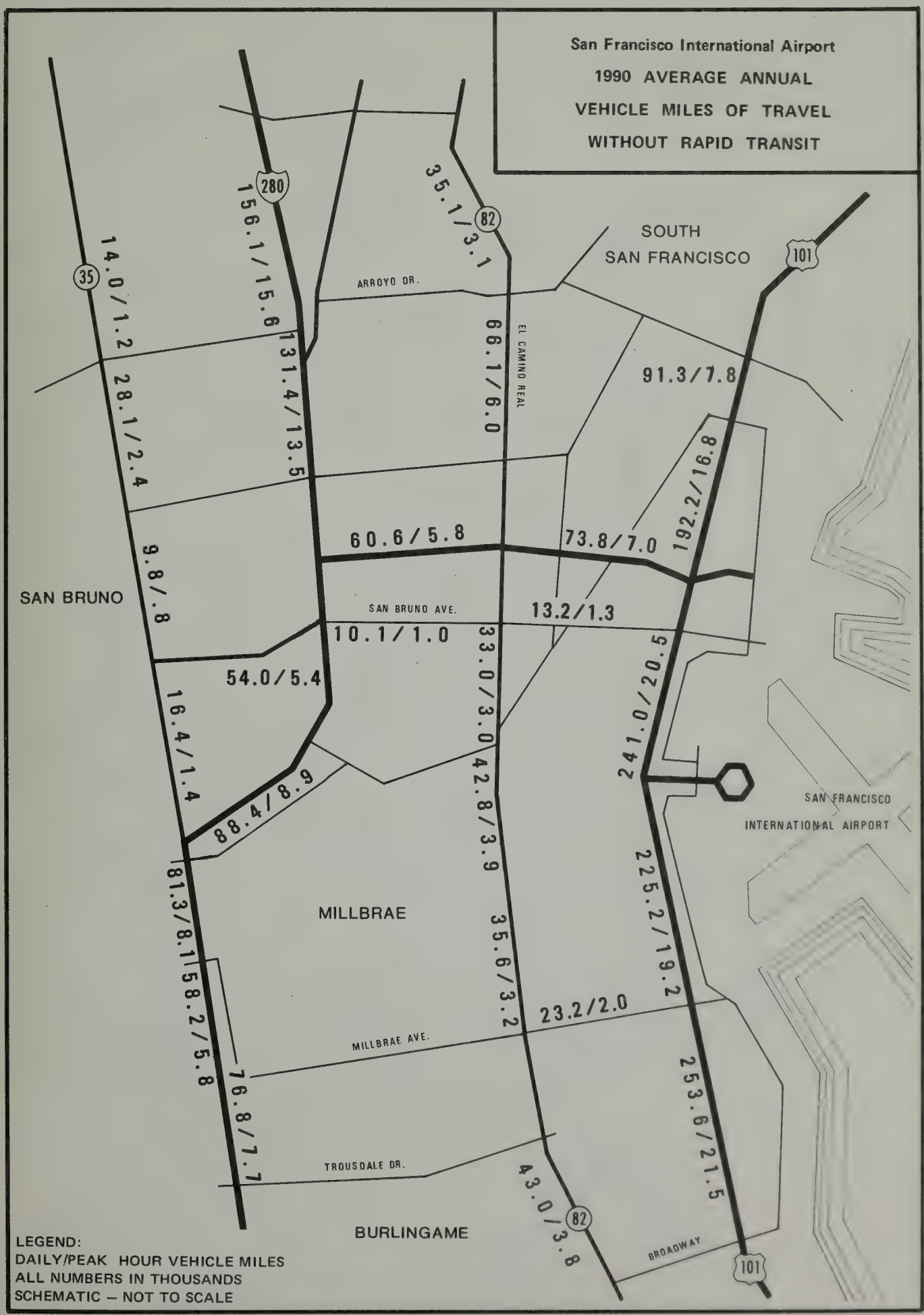

San Francisco International Airport
1974 AVERAGE DAILY
VEHICLE MILES OF TRAVEL
(UNDER CONST.)
I-380
9.5/.8
3.0/.2
SO. AIRPORT BLVD.
5.5/.4
24.3/2.2
SAN BRUNO AVENUE
12.5/1.4
2.2/.3
8.1/.9
3.6/.2
2.4/.2
4.4/.4
1.6/.1
A
A
U.S. 101
9.2/1.0
11.2/.9
MILLBRAE AVENUE
21.0/1.4
OLD BAYSHORE HIGHWAY
1.1/.1
4.9/.3
4.9/.3
0.8/.1
1.4/.1
4.3/.3
0.8/.1
3.9/.2
3.9/.2
0.7/.1
1.4/.1
1.8/.1
1.8/.1
1.5/.1
A
A
1.9/.2
3.7/.3
3.3/.2
LEGEND:
DAILY/PEAK HOUR VEHICLE MILES
ALL NUMBERS IN THOUSANDS
SCHEMATIC – NOT TO SCALE

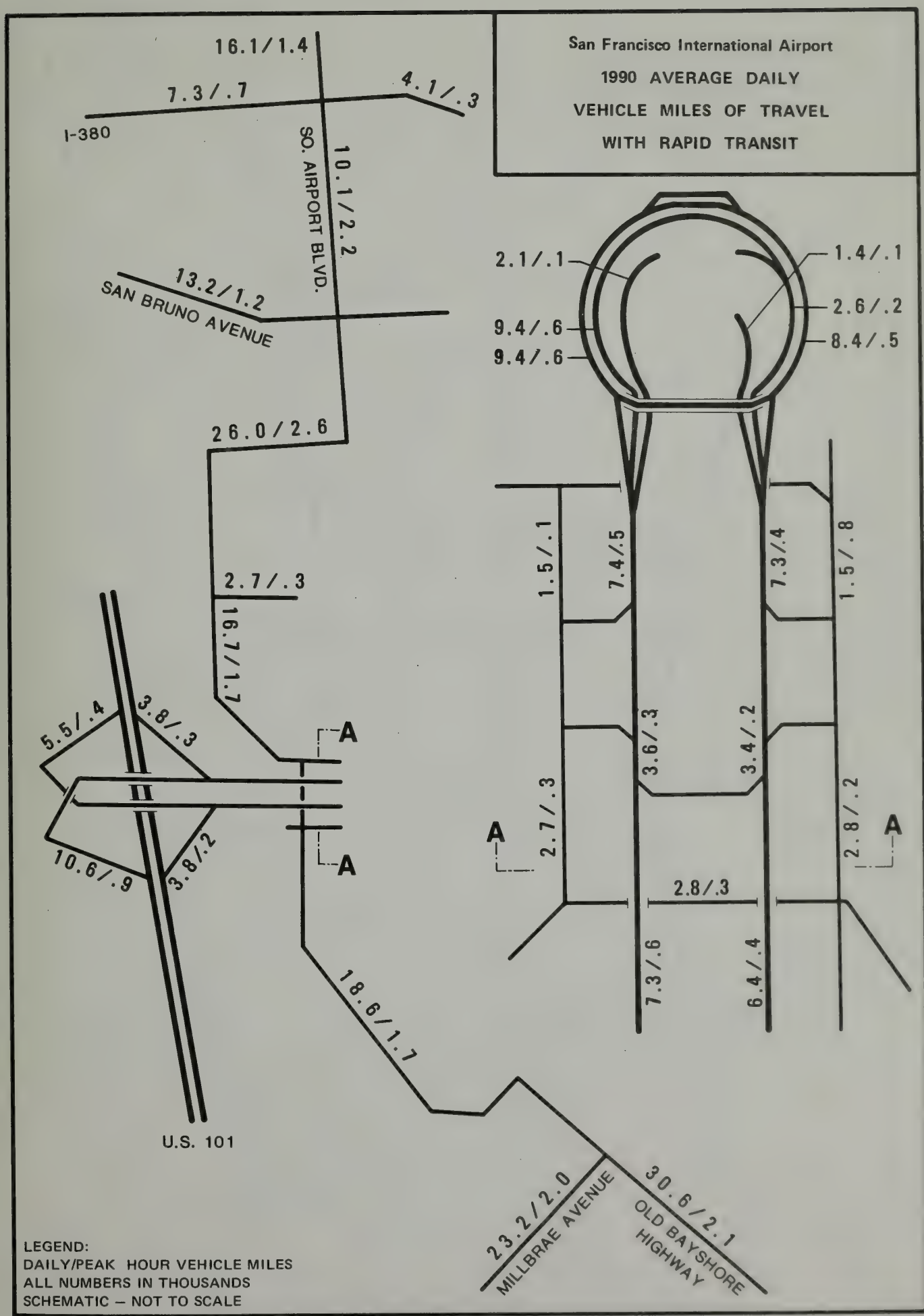

San Francisco International Airport
1974 AVERAGE DAILY
VEHICLE MILES OF TRAVEL
280
82
101
35
SOUTH
SAN FRANCISCO
ARROYO DR.
EL CAMINO REAL
SAN BRUNO
SAN BRUNO AVE.
MILLBRAE
MILLBRAE AVE.
TROUSDALE DR.
BURLINGAME
BROADWAY
SAN FRANCISCO
INTERNATIONAL AIRPORT
7.6/1.0
116.9/13.0
22.9/2.3
36.5/4.0
49.3/4.8
57.8/5.5
22.9/2.7
91.7/9.2
131.3/12.5
14.8/1.8
7.8/.8
8.1/1.0
12.7/1.5
12.4/1.2
30.9/2.5
13.6/1.1
17.4/1.6
186.9/17.8
27.6/3.3
13.5/1.7
45.1/5.5
38.5/3.6
166.1/15.8
44.1/4.9
31.4/3.0
18.8/1.7
30.0/3.0
40.3/4.0
187.7/17.8
42.0/4.0
LEGEND:
DAILY/PEAK HOUR VEHICLE MILES
ALL NUMBERS IN THOUSANDS
SCHEMATIC – NOT TO SCALE

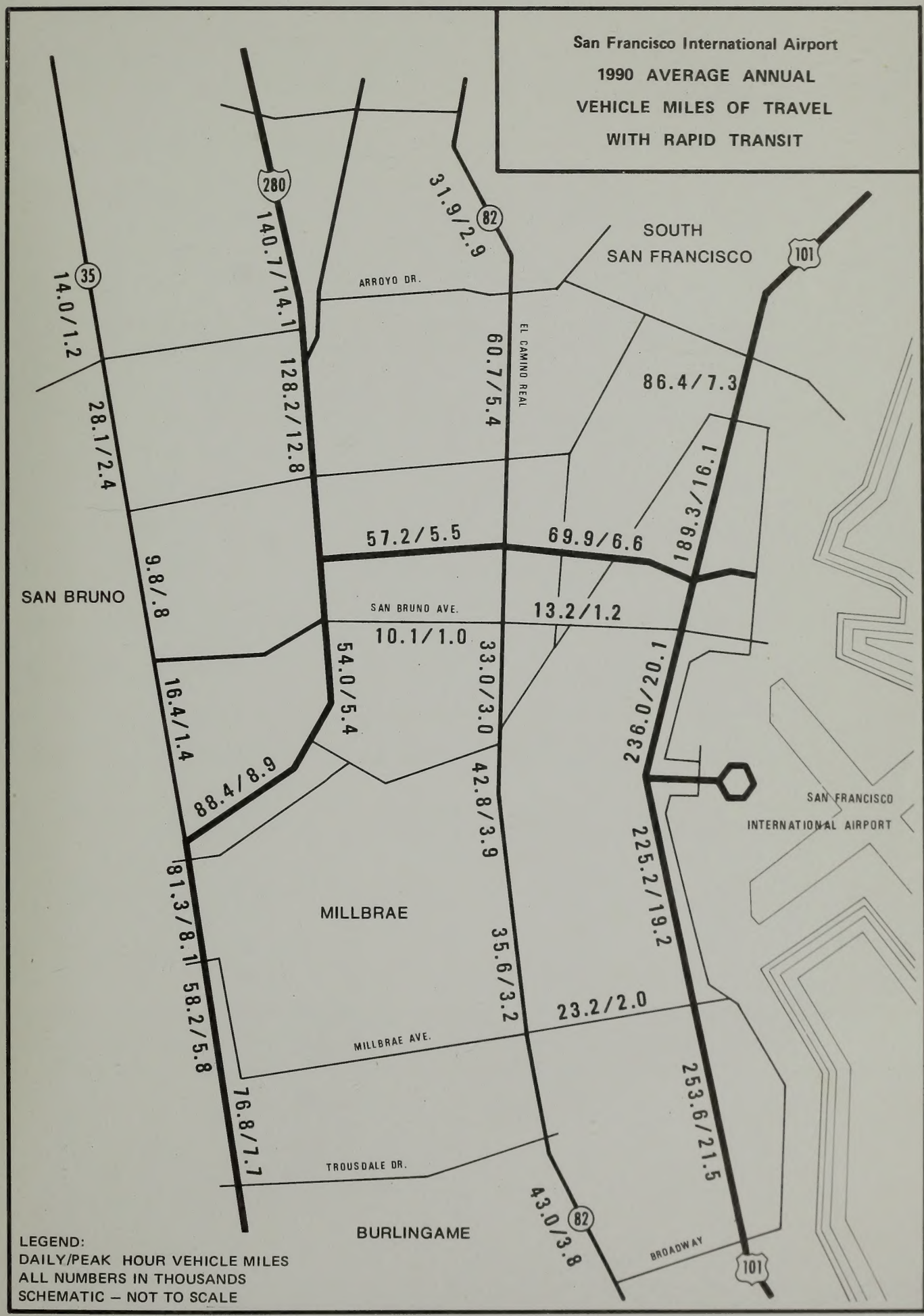
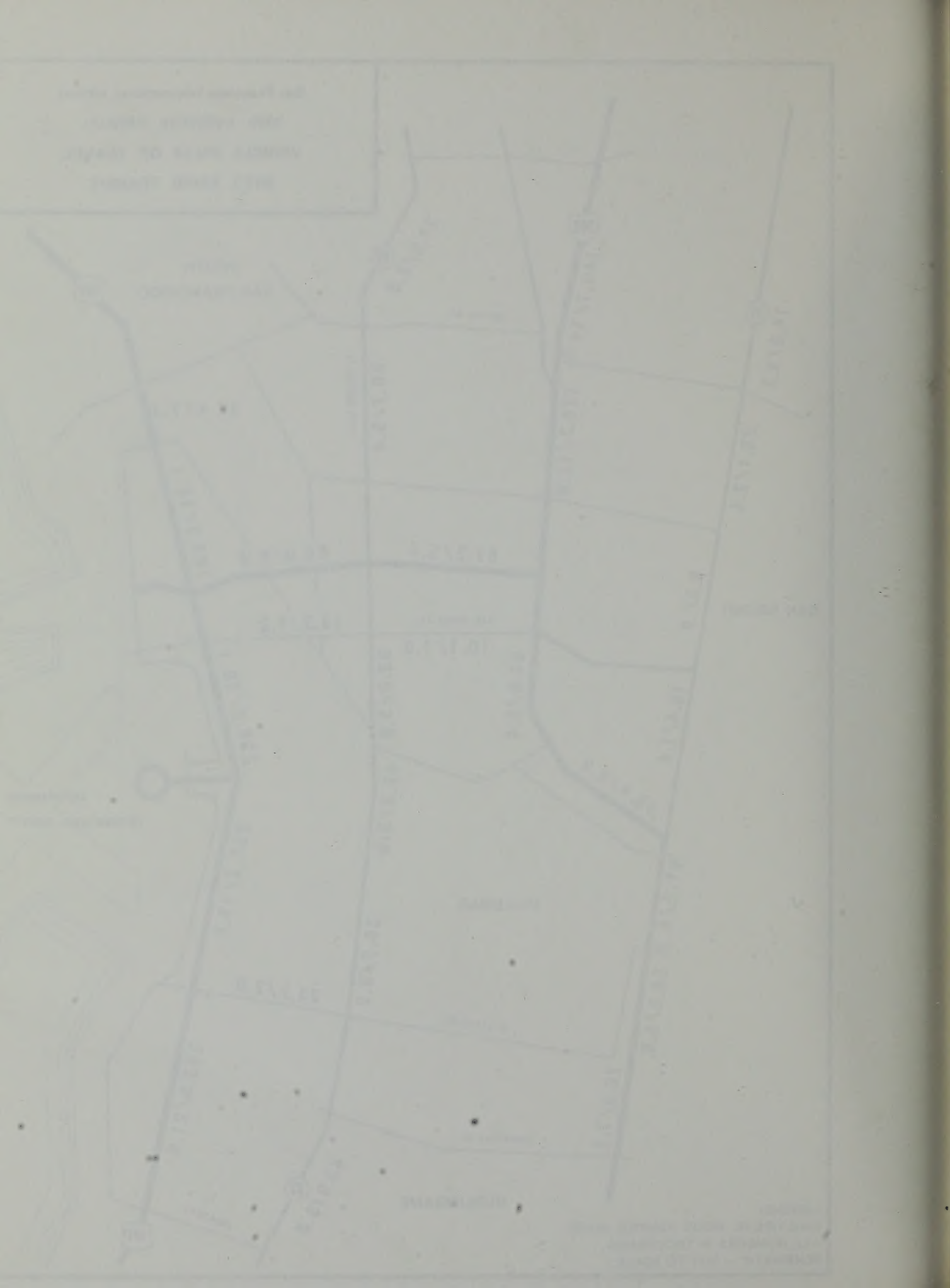

San Francisco International Airport
1982 AVERAGE DAILY
VEHICLE MILES OF TRAVEL
13.2/1.1
6.2/.6
3.1/.3
I-380
SO. AIRPORT BLVD.
7.6/.6
11.5/1.1
SAN BRUNO AVENUE
18.0/1.8
2.4/.3
11.7/1.2
4.3/.3
3.0/.2
1.5/.1
2.1/.2
A
A
1.6/.1
1.1/.1
6.6/.4
1.9/.1
7.0/.5
6.2/.4
1.0/.1
5.4/.4
5.4/.3
1.0/.1
1.9/.2
2.6/.2
2.5/.2
2.0/.2
A
A
2.1/.2
5.4/.5
4.8/.3
13.8/1.2
U.S. 101
14.8/1.2
MILLBRAE AVENUE
27.2/2.0
OLD BAYSHORE HIGHWAY
LEGEND:
DAILY/PEAK HOUR VEHICLE MILES
ALL NUMBERS IN THOUSANDS
SCHEMATIC – NOT TO SCALE


San Francisco International Airport
1982 AVERAGE DAILY
VEHICLE MILES OF TRAVEL
280
82
101
35
SOUTH
SAN FRANCISCO
ARROYO DR.
EL CAMINO REAL
SAN BRUNO
SAN BRUNO AVE.
MILLBRAE
MILLBRAE AVE.
TROUSDALE DR.
BURLINGAME
BROADWAY
SAN FRANCISCO
INTERNATIONAL AIRPORT
140.9/14.1
31.5/2.8
8.8/0.7
141.5/14.2
58.6/5.3
78.4/6.7
26.1/2.2
169.5/14.4
56.1/5.3
65.8/6.3
8.8/0.7
11.5/1.1
8.8/0.9
29.7/2.7
210.41/17.9
43.5/4.3
14.4/1.2
81.0/8.1
39.2/3.6
198.8/17.0
66.9/6.7
33.4/3.0
14.8/1.2
47.1/4.7
220.3/18.8
61.9/6.2
46.0/4.1
LEGEND:
DAILY/PEAK HOUR VEHICLE MILES
ALL NUMBERS IN THOUSANDS
SCHEMATIC – NOT TO SCALE


San Francisco International Airport
1990 AVERAGE DAILY
VEHICLE MILES OF TRAVEL
WITHOUT RAPID TRANSIT
16.3/1.4
7.3/.7
4.1/.3
I-380
SO. AIRPORT BLVD.
10.4/2.3
13.2/1.3
SAN BRUNO AVENUE
25.5/2.6
2.9/.3
16.8/1.7
6.5/.4
4.5/.4
10.6/.9
3.8/.3
A
A
U.S. 101
19.1/1.8
1.5/.1
2.2/.1
2.8/.2
10.3/.6
9.0/.6
10.1/.7
1.5/.1
7.9/.5
7.8/.5
1.5/.1
2.8/.3
3.9/.3
3.7/.2
2.9/.2
A
A
2.2/.2
7.9/.6
6.9/.4
23.3/2.0
MILLBRAE AVENUE
31.0/2.2
OLD BAYSHORE
HIGHWAY
LEGEND:
DAILY/PEAK HOUR VEHICLE MILES
ALL NUMBERS IN THOUSANDS
SCHEMATIC – NOT TO SCALE


San Francisco International Airport
1990 AVERAGE ANNUAL
VEHICLE MILES OF TRAVEL
WITHOUT RAPID TRANSIT
280
82
35
101
SOUTH
SAN FRANCISCO
ARROYO DR.
EL CAMINO REAL
SAN BRUNO
SAN BRUNO AVE.
MILLBRAE
MILLBRAE AVE.
TROUSDALE DR.
BURLINGAME
BROADWAY
SAN FRANCISCO
INTERNATIONAL AIRPORT
14.0/1.2
156.1/15.6
35.1/3.1
28.1/2.4
131.4/13.5
66.1/6.0
91.3/7.8
192.2/16.8
60.6/5.8
73.8/7.0
9.8/.8
13.2/1.3
10.1/1.0
54.0/5.4
33.0/3.0
241.0/20.5
16.4/1.4
88.4/8.9
42.8/3.9
225.2/19.2
181.3/8.1
58.2/5.8
35.6/3.2
23.2/2.0
76.8/7.7
253.6/21.5
43.0/3.8
LEGEND:
DAILY/PEAK HOUR VEHICLE MILES
ALL NUMBERS IN THOUSANDS
SCHEMATIC – NOT TO SCALE


San Francisco International Airport
1990 AVERAGE DAILY
VEHICLE MILES OF TRAVEL
WITH RAPID TRANSIT
16.1/1.4
7.3/.7
4.1/.3
I-380
SO. AIRPORT BLVD.
10.1/2.2
13.2/1.2
SAN BRUNO AVENUE
26.0/2.6
2.7/.3
16.7/1.7
5.5/.4
3.8/.3
10.6/.9
3.8/.2
A
A
U.S. 101
18.6/1.7
2.1/.1
1.4/.1
2.6/.2
8.4/.5
9.4/.6
9.4/.6
1.5/.1
7.4/.5
7.3/.4
1.5/.8
3.6/.3
3.4/.2
2.7/.3
2.8/.2
A
A
2.8/.3
7.3/.6
6.4/.4
23.2/2.0
MILLBRAE AVENUE
30.6/2.1
OLD BAYSHORE HIGHWAY
LEGEND:
DAILY/PEAK HOUR VEHICLE MILES
ALL NUMBERS IN THOUSANDS
SCHEMATIC – NOT TO SCALE


San Francisco International Airport
1990 AVERAGE ANNUAL
VEHICLE MILES OF TRAVEL
WITH RAPID TRANSIT
280
82
35
101
140.7/14.1
31.9/2.9
14.0/1.2
ARROYO DR.
SOUTH
SAN FRANCISCO
EL CAMINO REAL
60.7/5.4
128.2/12.8
28.1/2.4
86.4/7.3
189.3/16.1
57.2/5.5
69.9/6.6
9.8/.8
SAN BRUNO
SAN BRUNO AVE.
13.2/1.2
10.1/1.0
54.0/5.4
33.0/3.0
16.4/1.4
88.4/8.8
236.0/20.1
SAN FRANCISCO
INTERNATIONAL AIRPORT
42.8/3.9
225.2/19.2
81.3/8.1
MILLBRAE
35.6/3.2
23.2/2.0
58.2/5.8
MILLBRAE AVE.
253.6/21.5
76.8/7.7
TROUSDALE DR.
43.0/3.8
BURLINGAME
BROADWAY
LEGEND:
DAILY/PEAK HOUR VEHICLE MILES
ALL NUMBERS IN THOUSANDS
SCHEMATIC – NOT TO SCALE